ELEMENTARY PHYSIOLOGY AND HYGIENE

CONN

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AN ELEMENTARY PHYSIOLOGY AND HYGIENE

FOR USE IN SCHOOLS

BY

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PREFACE TO CANADIAN EDITION.

The aim of physiology and hygiene in the common Schools is to direct the minds of children to those rules of right living that make for good health. To understand these rules a knowledge of the structure of the body and the functions of the various parts is necessary. To give this knowledge in a way that can be followed intelligently by pupils of the senior grades is the purpose of the present work. The order of the topics and the mode of treatment make it a suitable guide for the teacher in the earlier grades where the subject is treated orally.

The results of the use of stimulants and narcotics are clearly pointed out in connection with the organs or functions affected, and care has been taken to see that in this, as in the treatment of all other subjects, the teaching of the book is in accord with the finding of the latest scientific investigations.

WINNIPEG, April, 1904.

AUTHOR'S PREFACE

THE aim of the author in writing the present work has been to furnish an elementary text-book in physiology and hygiene which should recognize some of the more important discoveries of recent years concerning matters pertaining to health, and which should also attempt to exemplify in the clearest way the inter-relation between physiology and hygiene.

The primary object of the study of physiology in our schools is to inculcate an intelligent care of the body. With this in view, matters of hygiene must in one sense take first place, although our understanding of hygiene must always be based upon a knowledge of physiology. In the present work the study of the body, and of its various parts and their functions, is given full and comprehensive treatment; at the same time lessons on hygiene are given as natural results of the principles of physiology and as closely related thereto.

The chapters upon foods and their values and the treatment of the causes and distribution of contagious and other germ diseases are included from the belief that these new lines of discovery are of such vital importance that they should be a part of the knowledge of every boy and girl.

The effect of alcohol upon the various functions of the body is treated throughout the book in direct rela-

tion with the particular organs or functions concerned. In this way, it is believed, the facts will be most clearly and usefully apprehended. The dangers connected with the use of alcohol will be found plainly indicated, and the statements, it is believed, are strictly in accord with the results of the latest investigations in that department of science.

The author desires to express his hearty acknowledgments to Superintendent W. P. Ferguson of Middletown and Dr. George W. Fitz of Boston for their kindness in looking over the proofs of the work and giving him the benefit of their criticisms. He wishes also to express his obligations to Professor W. O. Atwater, Professor William N. Rice, and Dr. F. G. Benedict of Wesleyan University, to Professor C. F. Hodge of Clark University, to the Rev. J. H. James, President of the Connecticut Temperance Union, and to Superintendent J. G. Edgerly of Fitchburg, Massachusetts, for their valuable suggestions. While acknowledging obligations to these gentlemen, it is not implied that any of them can be held responsible for the method of treatment in the work or as necessarily indorsing it or any part of it.

The expression of the author's thanks is also due to many teachers who have aided him by valuable suggestions arising from their practical experience.

CONTENTS

CONTENTS

ILLUSTRATIONS

PHYSIOLOGY AND HYGIENE

CHAPTER I

FOODS AND FOOD MATERIALS

OUR bodies are in some respects like an engine that is constantly at work. As an engine is cold and powerless without fuel, so our bodies without food would starve and die. As the engine usually works smoothly and strongly, so the body, when we are in good health, is strong and active. But sometimes the body, like the engine, breaks down in part, and cannot do all its work. Then we say that we are ill. Smooth action of the engine means *good health*. When anything interferes with its working properly, ***sickness*** results. If the machine stops entirely, we say there is ***death***. **Physiology** teaches us about the body, what the work of each part is; and **Hygiene** teaches us how we may treat the body wisely, just as the skilful engineer cares for his engine in the best possible way.

PURPOSES OF FOOD

When we speak of food, we ordinarily mean materials suitable for us to eat. In this chapter we shall include in the word "food," only the portion of the food

material that can be taken into the blood, and so give nourishment to the body, and not that which passes out as waste.

In order that an engine may be kept running, it is necessary, of course, that coal or other fuel be regularly supplied, so that the engine may continue to have heat under its boilers, and power to run. But the coal could not keep the wheels revolving if an important part of the engine should break down. The care of the engine, then, includes also the repairing or replacing of parts that break or wear out. In much the same way our bodies need not only heat and energy, but also the constant building and repair of parts which are used up from day to day. Our food supplies us with material for building and repair, as well as for heat and energy.

Foods for Building and Repair. — When you say, "I have grown two inches since last year," you mean that your bones and muscles have increased in size a certain amount during the last twelve months. Even after we have reached our full height, certain parts of the body still continue to grow. The hair and finger nails need frequent cutting, and the skin is all the time wearing away. Although we cannot see so readily that the bones and muscles wear out and require constant repair, it is equally true. It is necessary, then, that our bodies receive in food some **building material** which can be used to increase the size of growing muscles and bones, and to replace those parts that are worn out.

Foods for Fuel. — In addition to the material used for building and repair, our bodies need food that will serve as **fuel**, like the coal on the steamship, to supply heat, and power to use the muscles. Although we may feel so cold that our bodies fairly ache, as we say, still, as long as our hearts beat, that is, as long as we live, our bodies are always warm. If you look at a thermometer, you will see that a certain point on the scale is marked "blood heat." This means that the point marked 98½° is about the normal temperature of the blood. If the blood is cooler than this, we are ill; even a degree or two of additional heat in the body is fever. As we shall learn in a later chapter, our bodies are kept at the proper temperature by using up certain food materials, much as a stove or heater is warmed by the burning of coal. The flame which we see when wood or coal is burned is caused by the uniting of the fuel with a gas in the air which is called *oxygen*. In a similar way, but without flame, the heat-giving foods which we eat combine in our bodies with the oxygen which has been taken in with the air we breathe.

KINDS OF FOOD

The kinds of food which people eat appear to be numerous. As we study them carefully, however, we find that although our dinner table may hold a number of delicious things, the different articles of food are made up of a very few substances. Some of these substances, of which we shall learn more very soon, furnish our bodies with both building material and fuel, others chiefly with fuel.

Let us now consider these special food substances which are contained in the things we eat.

Foods used for both Fuel and Repair. Albumen. — If we break an egg carefully, we can separate the white from the yolk. This white, transparent, jellylike substance is known as **albumen**, and is a valuable food substance. The white of the egg is one of the purest forms of albumen, but though we cannot see it so readily, albumen is found in meat, milk, and other articles of food. If you heat the white of the egg, it becomes solid, undergoing a change called *coagulation.*

Myosin. — The lean part of meat after the gristle has been removed is another important food substance, and is called **myosin.** Uncooked myosin is soft and elastic; but cooking coagulates it, just as boiling hardens the white of the egg.

Gluten. — If we wrap a little flour in a piece of fine muslin and allow water to run through it, most of the flour will be washed away. A sticky, gummy, white mass will be left. This is **gluten.**

Casein. — Milk contains a food substance called **casein.** If we pour a little weak acid, like vinegar, into the milk, the latter curdles. The curd, or thick whitish substance, is casein. When pressed into cakes and dried in a certain way, it becomes cheese.

These foods, *albumen*, *myosin*, *gluten*, and *casein*, build up the body, help to keep it in repair, and serve also as fuel. They are called **proteids**, or nitrogenous foods, and without them the body would starve. It must not be supposed, however, that eggs, meat, flour, and

milk are the only proteid foods, since there is some proteid in almost all classes of foods. Peas, beans, lentils, and similar vegetables are very rich in proteids, and are for millions of people the cheapest and most convenient of proteid foods.

Foods used chiefly for Fuel. — A man might have the muscles of a Samson, but if he were unable to lift anything with his sinewy arm, or to run upon his well-built legs, he would be of no more use to the world than a statue. To enable us to use our muscles we need more than the building and repairing foods; we must give our bodies something that will supply warmth and muscular power. The proteids or building foods may be used partly for this purpose, but we have in addition three important food substances that act mainly as fuels,—**starch, sugar**, and **fats**. They furnish us with heat and the power necessary for motion. Although our diet cannot be confined to either class, we really need a larger amount of the fuel foods than of the proteids.

Starch. — Starch is found in certain of our vegetable foods, such as flour, oats, and potatoes. For use in the laundry and as stiffening for puddings, the starch is separated from the other substances found in potatoes and corn; we then call it either laundry starch or corn starch. We must remember, however, that starch is really present in every potato, every kernel of corn, and every grain of wheat. We can easily see whether starch is contained in a fruit or a vegetable by touching it with a drop of water containing a little

iodine.[1] If there is starch in the vegetable, the spot touched will turn blue. The starch always appears in the form of very minute grains. Figure 1 shows starch grains as they look when seen through a powerful microscope.

We can cook our starch by putting a little into water and boiling it. The heat swells the grains of starch and the mass becomes a thick paste.

FIG. 1.—STARCH GRAINS. As seen through a microscope.

Sugar. — Sugar, like starch, is a fuel food, although in appearance and taste the two differ widely. There are several kinds, the so-called *cane sugar*, made from sugar cane, being one of the sweetest. *Beet sugar*, manufactured from the sugar beet, is also of excellent quality. *Glucose* or *grape sugar*, which is found in fruits and in corn, is less sweet than cane or beet sugar, but as it is more cheaply prepared for market, it is often used for adulterating other sugars. Milk contains a kind of sugar known as *milk sugar*. All sugars are of about equal value as foods, despite their different degrees of sweetness.

We can readily observe a difference between sugar and starch by placing a little sugar in water and heating gently, and then repeating the experiment with starch. The sugar quickly dissolves, while the starch

[1] A few drops of tincture of iodine in a teaspoonful of water is sufficient for a number of tests.

does not, but, as we have already seen, swells if the heat is sufficient.

Starch and sugar, though so different in some respects, are closely related and have much in common. Starch is changed to sugar in fruits as they ripen, in seeds and bulbs as they grow, and the same process takes place in our starchy foods as they are digested.

Fats. — Fats are among the very best fuel foods. It is because of its excellent heat-giving qualities that the Eskimos eat so much of the blubber or fat of seals and other animals; the fat enables them to endure the severity of their cold climate. *Butter, tallow, lard, olive oil,* and *cottonseed oil* are fats. Some of the fats used as foods, such as butter and lard, come from animals; and others, such as olive and cottonseed oils, from the vegetable world. Several of the fats, like lard, are solid when they come from the market, becoming liquid only when subjected to heat; others, like olive oil, are always liquid.

Animal fat is made up of little drops, each inclosed in a sac. The sacs can be seen only with the aid of a microscope. Figure 2 shows a group of **fat cells** as they thus appear; the figure shows five fat drops in their sacs, in the form in which they are found in animal foods, such as a piece of beefsteak. We must remember, however, that when we

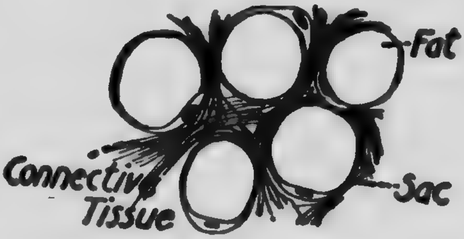


FIG. 2. — FAT CELLS.
As they appear in a piece of meat under a microscope.

look at animal fat it is solid and white because it is cold. In the living animal it is liquid, because of the heat of the body, and it is transparent.

Melted fats or oils, when mixed with certain liquids, break up into very small drops, making the liquids look white. The millions of minute fat drops in milk aid in giving the liquid its white color.

To test this, place a few drops of olive oil or castor oil and some water in a small bottle and shake rapidly. Then let it stand for an hour or so and note the change.

Material for Bone Making. — As we shall see later, bones are made up of two widely different materials. Part of the bone, what is called the *organic* matter, is made up from the proteids which are so useful in building up other parts of the body. The harder mineral matter of the bone is *lime*, which is contained in small quantities in such common foods as meat, bread, milk, and eggs. Thus our ordinary food furnishes us with all material needed for bone building.

SOURCES OF FOODS

Although the substances about which we have just been studying are the foods necessary to sustain life, we seldom eat any one of them singly or in a pure form. Take bread, for example. As usually made, it contains flour, milk, sugar, lard, and salt. The flour gives us starch and gluten, the milk casein and sugar, the lard fat. And so it is with almost everything we eat. Usually several food substances are to be found in each single article of diet. See tables, pages 33-35.

Foods come both from animals and from plants. The principal animal foods are **milk**, **meats**, and **eggs**.

Milk. — Milk is one of the cheapest and best of foods. We may be sure, as it is the natural food for babies, that it is easily digested and contains all the materials necessary for life, growth, and activity. The curd is the *body-building* food, and the cream, or fat, and the milk sugar are the *force-producing* foods. We should always remember that milk should be used as a *food*, and not to take the place of water as a drink to quench thirst.

Milk should usually be the chief food for a child until his first teeth appear. When he becomes active and begins to walk, milk does not furnish enough *force-producing* material, and this must be obtained from starchy foods, such as bread, crackers, and other cereal foods

The fat or cream may be allowed to rise to the surface of the milk and can then be taken off and churned into *butter*. The *skimmed milk* remaining still holds most of the sugar and just as much of the building food as could be found before the cream was removed; therefore it remains a valuable food. Skimmed milk contains a little less fuel substance than does new milk, but it is equally serviceable for body building. It is so cheap that it is a valuable food for those who have but little money to spend. The curd, when separated from the rest of the milk, is pressed and dried to make *cheese*. Both cheese and butter are very useful foods.

Danger in Milk. — Since milk is capable of holding and transmitting the germs of certain diseases, it is sometimes a source of danger. Typhoid fever, diphtheria, scarlet fever, and tuberculosis (consumption) are occasionally caused by impure milk. Much of the illness suffered by babies and little children in warm weather may be traced to milk which has been made impure by a lack of cleanliness about milkmen, cows, barns, milk-houses, or milk-cans. It is necessary that milk, and all utensils holding it, should be kept perfectly clean. Some dealers send men to inspect the farms from which they obtain milk, to see that everything about the dairy is kept neat.

To avoid these dangers, milk should be bought from a reliable dealer. It should be kept cold until used, and all dishes in which it is to stand should be washed with *boiling water* before the milk is put into them. It is wise also, especially in warm weather, to "scald" the milk which is to be used by young children or invalids. This removes much of the possibility of danger, and is very little trouble, as the milk needs only to be brought to the boiling point (but not boiled) and then cooled. Milk that has been boiled is not so wholesome as milk that has merely been "scalded."

Meats. — Common meats consist of **lean substance**, or **flesh**, with some fat and considerable water. The flesh (myosin) is one of our most valuable body-building foods. So far as the amount of useful food is concerned, cheap meats are as nourishing as the more expensive cuts. A pound of round steak will

give us just as much good food as an equal quantity of porterhouse steak. The extra money for high-priced meat is paid largely because these cuts are more tender than the cheaper parts and because the taste is in some respects better.

Eggs. — Albumen and fats are the principal foods in eggs. When cooked but a little, whether boiled in the shell or dropped into hot water, eggs are healthful and nourishing. Hard-boiled eggs are less easily digested, because the juices of the stomach do not act readily upon the tough, coagulated mass. When very thoroughly chewed, however, they are more readily digested.

Plant Foods. — A large part of our food comes from plants. The most important of the plant foods are **grains** or **cereals.** The chief cereals eaten in this country are *wheat*, *oats*, *rye*, and *corn* (which are ground into flour, graham meal, oatmeal, rye meal, and Indian meal), and *rice*. In the countries of eastern Asia rice is the chief cereal used for food.

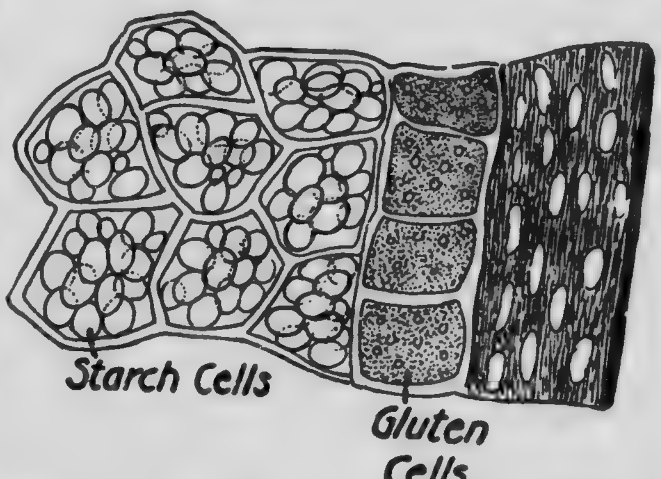


FIG. 3. — A SMALL BIT OF A GRAIN OF WHEAT. Highly magnified.

All cereals contain a large proportion of starch, or fuel food, and a small amount of the building materials, such as gluten. *Wheat* is one of the best cereals, since it has more gluten (that is, more building food) than most of the others. Figure 3 shows a small piece of a grain of wheat as it appears under the microscope. Some of the cells, as indicated, are loaded with starch, and others, fewer in number, contain gluten. About one eighth of our wheat flour is gluten. *Oats* (Fig. 4) are even better food than wheat, containing, as they do, a still larger proportion of gluten. *Rice* furnishes less building food than wheat, but more fuel food (starch). *Corn* contains also considerable fat.

FIG. 4. — THE OAT PLANT.

All of these cereals are thus excellent foods. They give us more fuel than meat and eggs, but less of the proteids or building foods. *Wheat bread* supplies a good proportion of the necessary materials for fuel and repair. A person could keep from starvation on a diet of bread and butter alone, but a variety of foods is always desirable. Meat and cheese go well with cereals, since they furnish the proteid and fat elements lacking in the grains.

Beans and Peas. — As *beans*, *peas*, *lentils*, and *peanuts* contain large quantities of starch and proteids, they are especially nourishing foods. More than one fifth of the substance of the bean is proteid, a larger proportion than is contained even in meat. Although they are not so easily digested as meat, they serve as an excellent substitute, and they are cheaper.

Fruits and Vegetables. — Although most *fruits* and *vegetables* contain little of the real food substances, they stimulate the appetite and thus give relish to the more substantial foods. They are composed largely of water, with a small amount of starch or sugar, flavoring matter which makes them pleasant to the taste, and also certain salts which aid digestion.

Some of them, however, such as potatoes, beets, bananas, cocoanuts, and nuts, contain sufficient starch, proteid, sugar, or fat to be valuable as foods. Indeed, vegetables and acid fruits seem to be needed by the body, as sailors or explorers, when deprived of them, suffer from scurvy and other diseases.

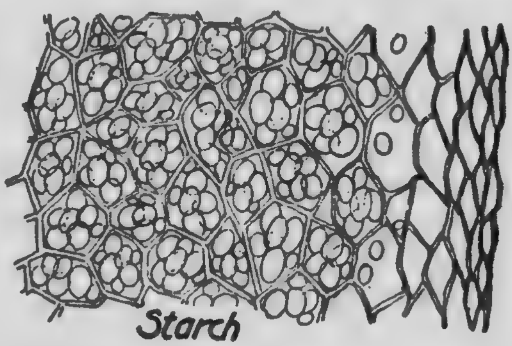


Fig. 5. — A Small Bit of Potato. Highly magnified. Showing cells filled with grains of starch.

Figure 5 represents a bit of potato magnified, showing the grains of starch. As the potato consists so largely of starch, it is a fuel food, and we should eat with it meat, milk, cheese, or

some other food which will supply proteids for the building material which the potato lacks.

We may eat freely of *fruits* if they are ripe and perfectly sound, but unripe and overripe fruits are unwholesome and injurious to health.

OTHER FOOD MATERIAL

There are certain other substances which we eat or drink that are not true foods. Some of them are necessary to life, some of them are of use, others may be harmful. Let us see what some of these are.

Water. — The shipwrecked sailor who is cast ashore on a rocky island or drifts about in an open boat can live for many days without food, but without water he soon becomes almost crazed with thirst, and in a very few days he dies. Our blood, muscles, and vital organs all contain water. Without this necessary fluid, the foods eaten could not be dissolved and thus made ready for transformation into blood and muscle.

The various other drinks, such as milk, soda water, beer, and wine, allay thirst only because of the water they contain, and none of them is equal to water itself for this purpose. If we quench our thirst with water only, we are not so likely to drink too much as we are when we attempt to satisfy ourselves with liquids containing other material. When we drink something that has an especially pleasing taste, the pleasure of taste may lead us to drink more than is wise.

Cool water is one of the most refreshing of drinks on a hot day, but extremely cold water, if taken in large

quantities when the body is overheated, may produce a shock which is harmful. Ice water or other cold water should be drunk very slowly. After violent exercise in the hot sun, it is wise to wait for a few minutes before drinking cold water.

Impurities in Water. — It is not easy to find absolutely pure water. Some of the impurities in drinking water are harmless; others are very injurious. Water sometimes contains certain minerals which it gets from the earth. These make the water "hard"; but though hard water sometimes produces slight bowel troubles, it is not especially harmful.

The most dangerous impurities in water are minute living plants called **bacteria**. Some of these, as we shall notice in a later chapter, may produce disease, if they are taken into the body. One kind of bacteria, occasionally found in drinking water, gives rise to typhoid fever. It is impossible to judge either by the appearance or by the taste, whether water does or does not contain injurious bacteria. It may be perfectly clear and of the finest taste, and yet be unsafe to drink.

Spring water is almost always pure, if the spring is deep and a good distance from any foul place, such as an open drain or a barnyard. The *lakes* and *reservoirs* from which cities obtain water are usually kept in good condition by the authorities; if at any time the water becomes unfit to drink, people are advised to boil it. *Wells*, particularly if they are on a lower level than the houses or barns for which they supply water, are likely to contain injurious bacteria. These may either pass

down through the soil or drain into the wells from the surface. *River water* is usually unfit to drink, especially if there are towns or cities on the banks that allow sewage to pour into the stream. Such water can be made healthful only by boiling. The dangerous bacteria are destroyed by heat. When typhoid fever prevails, it is always a wise precaution to boil the drinking water.

Mineral Substances. — Several mineral substances, called *salts*, are needed by the body in small amounts. **Lime** is required to make bone. We eat common **salt** with most of our food. Although salt neither builds up the body nor supplies fuel, it is absolutely necessary for health. Cattle will eat the grass grown on salt marshes, in spite of its coarseness, because they like the salty taste. Our ordinary food contains sufficient lime for bone material, as well as whatever other salts, aside from common salt, the body requires.

Flavors. — While we do not partake of food simply because we enjoy eating, still the different articles of diet give us a certain pleasure because of their various flavors, and indeed some flavor to our foods is necessary to enable us properly to digest them. The taste of puddings, cakes, pies, and similar dishes is due largely to certain substances added to give a desired flavor. The most common of these flavorings are lemon, vanilla, and spices. Tea and coffee are liked partly because of their pleasant taste, partly because of their slight stimulating effect. Young people are better off without them, and taken in excess they are

injurious to the nerves and the digestion of every one. Chocolate, in addition to having a fine flavor, contains real food.

ALCOHOL

Alcohol is a clear, transparent liquid, in appearance resembling water, but very different from water in its nature and effects. Although alcohol is found in smaller or larger quantities in various materials used for drinking purposes, it will neither quench thirst nor take the place of water in the body. Pure alcohol has a strong odor and an unpleasant taste.

Although alcohol and water appear so much alike, we can test the difference: 1. By smelling them — water is odorless, while alcohol has a pungent odor. 2. By pouring a few drops of alcohol and water into saucers and applying a lighted match — the alcohol burns. 3. By putting salt into water and also into alcohol — upon being shaken gently, the salt dissolves in the water, while in the alcohol it remains undissolved. Similar results are obtained if we substitute sugar for salt.

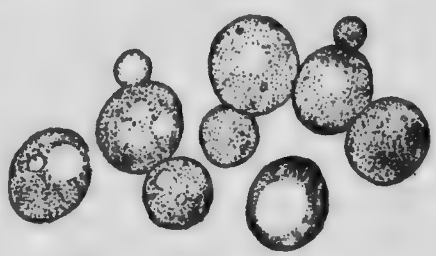


FIG. 6. — YEAST PLANT. Highly magnified.

How Alcohol is made. — Alcohol is made from sugar by a process called *fermentation*. The fermentation is brought about by a minute plant called *yeast*, to be seen only with the aid of a microscope. The common yeast which may be purchased at the grocery store con-

sists of many hundreds of thousands of these tiny plants (Fig. 6). If a bit of yeast is placed in a syrup made of water and sugar or molasses, the yeast grows, feeding on the sugar and very decidedly changing in its nature. Bubbles of gas rise through the liquid in which the yeast is growing (Fig. 7). Besides this gas there is produced at the same time a certain amount of *alcohol* which remains in the liquid. When the syrup has become entirely fermented, the sugar has disappeared and alcohol has taken its place.

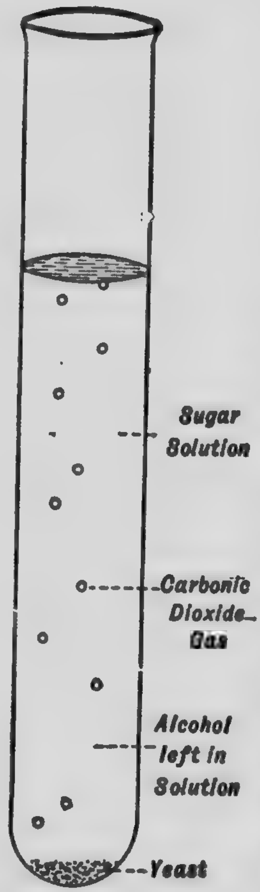


FIG. 7.—Sugar solution undergoing fermentation by yeast.

It is not always necessary to add yeast in order to start fermentation. Grape juice is changed into wine and apple juice into cider without any yeast being put into them. But in these cases a *ferment* gets into the juice from the air. These air ferments are in reality almost the same thing as the yeast from the store. Like yeast they are tiny plants, so small and light that they are blown about in the air and are always ready to act upon sugary liquids if they fall into them.

Fermented and Distilled Liquors. — Alcohol is found in many kinds of drinks. Such drinks are usually called **liquors**. They are always made by the fermentation of some such substance as *sugar*, *molasses*, *malt*,

corn, *grape juice*, or *apple juice*. These materials are fermented by yeast which is sometimes added directly to them, and sometimes gets into them from the air. In the latter case the fermentation is not so rapid as in the former. All the liquids contain alcohol as soon as they begin to ferment, whether they have been mixed with common yeast or whether they simply contain ferments from the air.

The mixtures thus fermented are employed in various ways. They may be used for drinks just as they are. This is the case with *beer*, *ale*, *wine*, and *cider*. Such drinks are called **fermented liquors.** The amount of alcohol which they contain ranges from one fiftieth to one fifth of the total volume of the liquor. The rest of the material is principally water, the amount of solid matter dissolved in the mixtures being small (Fig. 8).

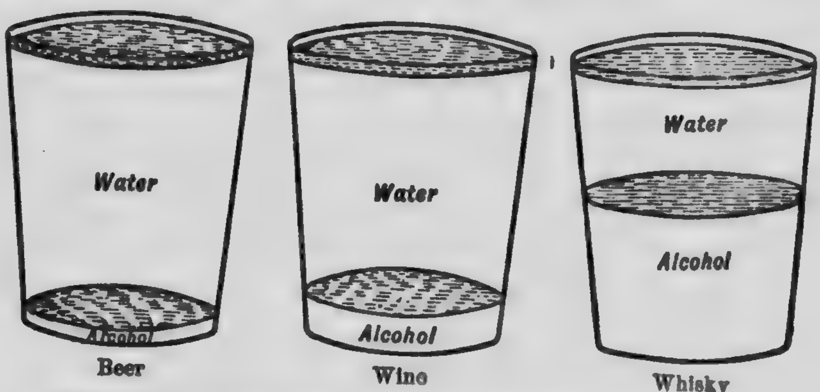


Fig. 8. — Showing the proportion of alcohol and water in beer, wine, and whisky.

Certain drinks called **distilled liquors** are made from fermented mixtures. By the process known as distilling, a part of the water is taken away, thus

leaving a larger proportion of alcohol in the mixture. The strength of the liquor depends, of course, upon the amount of alcohol which remains. The proportion of alcohol in the distilled liquors used as drinks varies from one quarter to one half. The rest of the material, which is chiefly water with a little flavoring matter, contains nothing useful except the water itself. The distilled liquors include *rum*, *whisky*, *gin*, and *brandy*. Because of their large proportion of alcohol, such drinks are even more harmful than fermented liquors. A small amount of whisky will intoxicate much more quickly than a large amount of beer or ale.

There is nothing in either fermented or distilled liquors that makes them necessary to any person in sound health. The boy or girl who wishes to be as vigorous, as useful, and as successful as possible should let them alone.

Why People drink Alcohol. — Although when taken in small quantities alcohol acts as a fuel, the danger that attends its use is so great that it is unwise to use it for food purposes. Men do not drink alcohol because it gives heat and power. A few cents' worth of bread will supply more heat and muscular strength than can be obtained from a much larger sum of money spent for any form of alcoholic drink. The alcoholic drinks may perhaps quench thirst, but it is only because of the water they contain, and water would serve the purpose much better if used alone.

Why, then, are alcoholic drinks used? In the first

place some persons enjoy the taste, although pure alcohol is unpleasant to the taste, and most beers and wines are disagreeable at first to the majority of people. Then there are those who enjoy the excitement which the alcohol produces, and there are others who have become so accustomed to using alcoholic drinks that they find it difficult to overcome the habit. It is here that the greatest danger in using alcoholic liquors lies. They are apt to create an appetite for more and more alcohol. Some people do not fall victims to this appetite; others, who seem to be just as strong and as capable of resisting the appetite, are finally mastered by it. No one is so safe from this danger as he who never begins to use alcoholic drinks.

People do not drink alcohol because they consider it valuable as a food, but because they like the taste or the exhilaration it produces, or because they cannot overcome the appetite for it.

AMOUNT OF FOOD NEEDED

How much food we should eat is a question not easy to answer. The amount depends somewhat upon a person's occupation. If a locomotive is running fast, it needs more fuel than if it moves more slowly, and when it stops, it requires only sufficient coal to keep the fire burning. So long as we live, our bodies never entirely cease action, for the heart always continues to beat; but at certain times we are more active than at others, and when we are hard at work, more food is required than when we rest. A poorly fed person

cannot do hard work. If a man, from a false idea of economy, subsists largely upon starchy foods, like potatoes and rice, he will be unable to do as much hard work as his neighbor whose diet contains more of the muscle-building materials. The man of small income should spend more of his money on beans or cheese, or perhaps on skimmed milk, as these will aid in supplying strength for muscular work.

The using of the body substance for muscular strength can be tested with the aid of scales. If a boy be weighed carefully before taking active exercise for an hour or two, and again after the exercise, the scales will show a difference in his weight. If the weighing is accurate and the boy has taken neither food nor water between the two weighings, the scales show just how much of the body substance has been used up during the muscular action, and consequently how much food and water are required to replace the loss.

Cheap and Costly Foods. — The cheapest food is not necessarily the one that costs the least money, but the one that gives us the greatest food value in return for a given outlay. In this sense the cheapest foods are beans and peas, since they cost little and yet give us a large amount of body-building material. Meats, on the other hand, although nutritious, are more expensive.

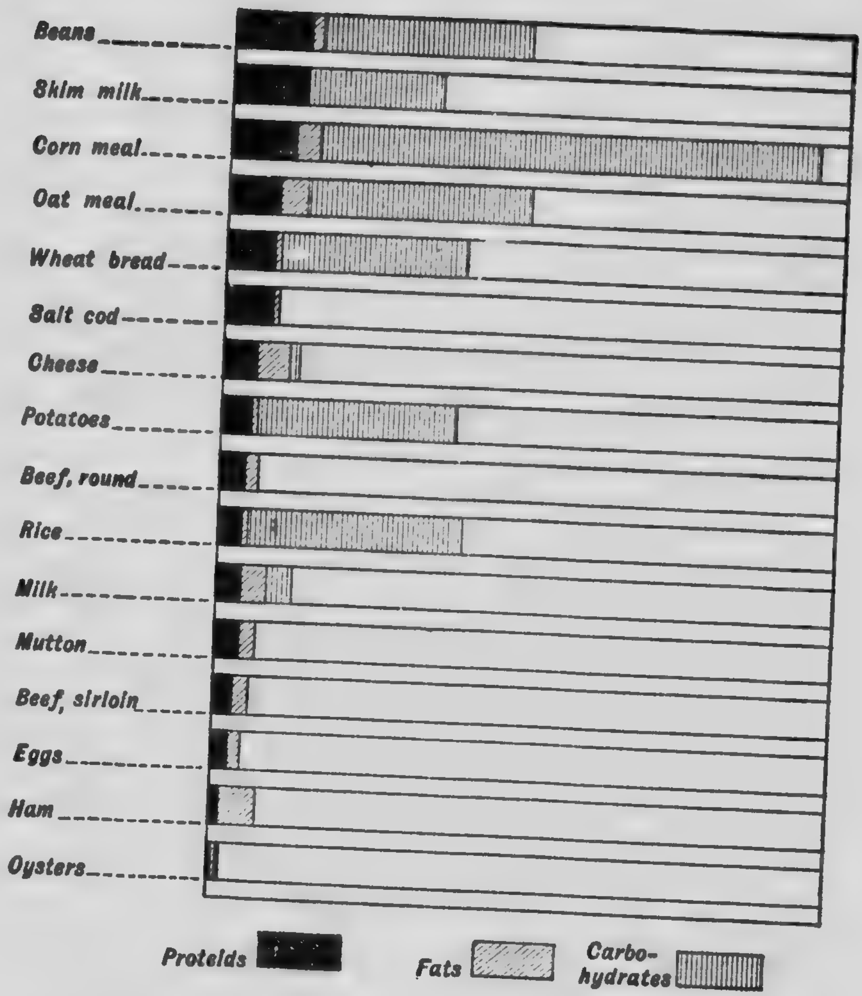
COMPARATIVE FOOD VALUES

The following table shows the food values which can be obtained for ten cents: —

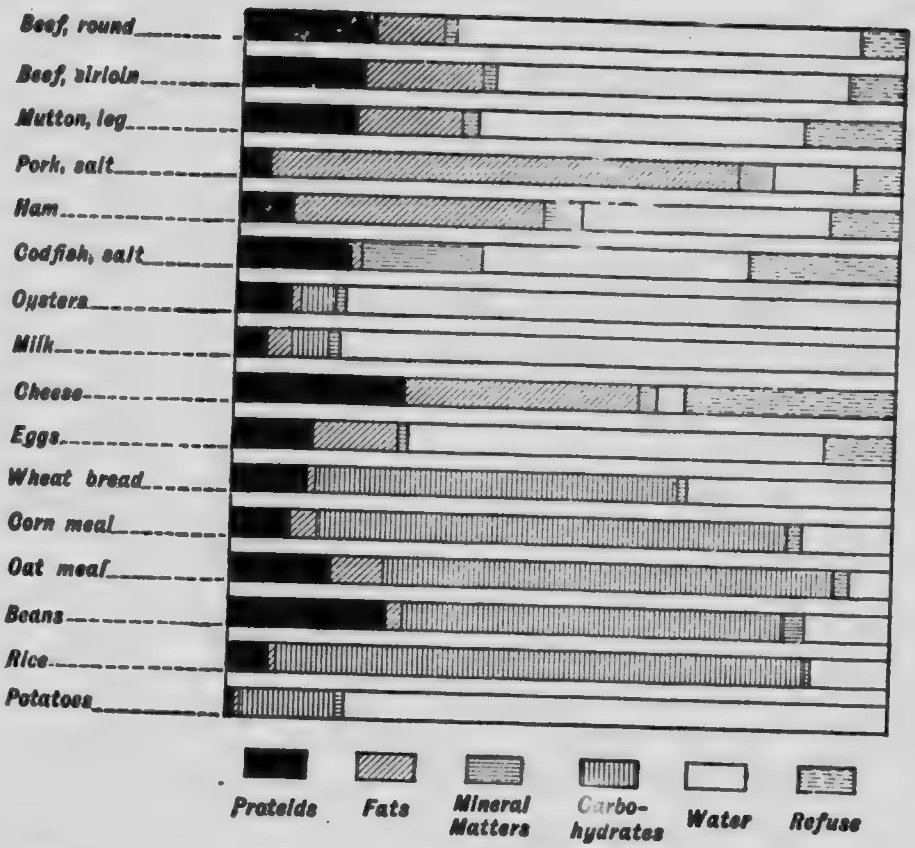
COMPARATIVE COST OF DIFFERENT FOOD MATERIALS AT AVERAGE PRICES.

Kind of Food Material	Price per pound	Cost of 1 pound proteids[1]	Amounts for ten cents			
			Total weight of food material	Proteid	Fat	Starch
	Cents	Dollars	Pounds	Pounds	Pounds	Pounds
Beef, sirloin	25	1.60	0.40	0.06	0.06	–
Beef, round	16	.87	.63	.11	.08	–
Mutton	16	1.10	.63	.09	.09	–
Pork	18	1.30	.56	.08	.18	–
Pork-fat, salt	12	6.67	.83	.02	.68	–
Butter	25	25.00	.40	–	.32	–
Eggs, 24¢ a doz. . . .	16	1.39	.63	.07	.06	–
Cheese	16	.64	.63	.16	.20	.02
Milk, 6¢ a qt.	3	.94	3.33	.11	.13	.17
Wheat flour	3	.31	3.33	.32	.03	2.45
Corn meal, granular . .	2½	.32	4.00	.31	.07	2.96
Wheat breakfast food . .	7½	.73	1.33	.13	.02	.96
Oatmeal	4	.29	2.50	.34	.16	1.63
Rice	8	1.18	1.25	.08	–	.97
Wheat bread	5	.64	2.00	.16	.02	1.04
Beans, white dried . .	5	.29	2.00	.35	.03	1.16
Corn, canned	10	4.21	1.00	.02	.01	.18
Potatoes, 60¢ a bush. . .	1	.67	10.00	.15	.01	1.40

[1] The cost of one pound of proteids means the cost of enough of the given material to furnish one pound of proteids, without regard to the amounts of other food substances present.



This table shows the comparative amount of the different food materials which can be purchased for ten cents. It shows that beans give the most proteid for the money and oysters the least.



This table shows the amount of the different food materials contained in the different foods. From this it will be seen that cheese is the most nutritious food. Beef is also very nutritious, but its high price makes it an expensive food, as is shown by the table on page 34.

QUESTIONS

1. For what purposes do we need food?
2. What are the two classes of foods?
3. In what respect is meat a valuable food?
4. Why are beans especially useful as foods?
5. If we drink skimmed milk, what food will go well with it?
6. Of what use to the body are starch, sugars, and fats?
7. With what does albumen furnish the body?
8. Why is milk made more healthful by boiling?
9. Why do people buy porterhouse instead of round steak?
10. What food substances do we get from cereals?
11. Why are potatoes so widely used as foods?
12. Which would be the best meal: one made up of potatoes and rice, or one of potatoes and beans?
13. Why are not potatoes alone a good diet? What kind of food should we eat with them?
14. What is the chief use of fruits and vegetables?
15. Why do we need to drink water?
16. How can impure water be made fit for drinking?
17. What does alcohol look like? How is it made?
18. Why do people use alcoholic drinks?
19. What food do we get from cheese? What does this food do for the body?
20. If you had one dollar to spend for a meal for four persons, what would you buy to make the most useful meal? (Consult tables on pp. 33–35.)

CHAPTER II

DIGESTION

BEFORE the bread and butter which we eat for breakfast becomes the blood and later the muscle of our body it meets with a number of changes. The process by which the food taken into the body is changed so that it can be absorbed into the blood, and thus be used for growth, repair, and warmth, is called **digestion**. Certain organs of our body have charge of this work and are called the **digestive organs.**

THE MOUTH

The food is received into the **mouth**, where the first step is taken in preparing it to enter the blood. The mouth is a large cavity with the **cheeks** for its sides, the **tongue** for a floor, and the **palate** for a roof. The front part of the palate is a hard, flat bone. The back part is a soft membrane, with a little finger-like piece called the **uvula** hanging from the middle and reaching almost to the tongue. (See Fig. 10.)

The Teeth. — Around the sides and front of the mouth are two rows of teeth fastened securely in sockets in the jawbones. The front teeth have sharp edges for *cutting* or *biting* food, while those farther back

in the mouth have broader surfaces and are used for *grinding* or *chewing* the food into a fine mass. Each tooth consists of a **crown**, the part we see as we look into the mouth; a **neck**, which is surrounded by the gums; and a **root**, which fits into the socket in the jawbone. Each tooth has a tiny blood vessel entering through its root, and is also supplied with a nerve. When the nerve is exposed to the air as a result of decay, the tooth may ache. The crown of the tooth is covered with **enamel**, the hardest substance in the body.

Growth of the Teeth. — In the course of life we have two sets of teeth. The first, or **milk teeth**, begin to grow when the child is five or six months old, and they continue to appear, one after another, for about three years. The milk teeth are twenty in number. When the child is about six years of age, the second, or **permanent teeth**, begin to push their way through the gums; the milk teeth are gradually loosened as the others push their way out. The first of the permanent teeth, called the "six-year molars," come so early that they are often mistaken for the last of the milk teeth. The permanent teeth are thirty-two in number.

Figure 9 shows the permanent teeth. Their arrangement, as can be readily seen from the figure, is as follows, beginning at the middle of the upper set: two **incisors**, one **canine**, two **bicuspids**, and three **molars**. The other side of the upper row is similarly arranged, and the lower jaw holds sixteen teeth to match these, with names corresponding. Notice the sharp edges of the front teeth and the broad grinding surfaces of the

double teeth farther back; also the six-year molars. If you shut your teeth tightly together, you will appreciate how well the upper and lower teeth match. The edges of the upper front teeth slip over those of the corresponding lower teeth, so that the food may be bitten off as if cut by scissors. The projections of the upper back teeth are opposite the hollows of the corresponding lower ones, so that the food may be ground fine without difficulty.

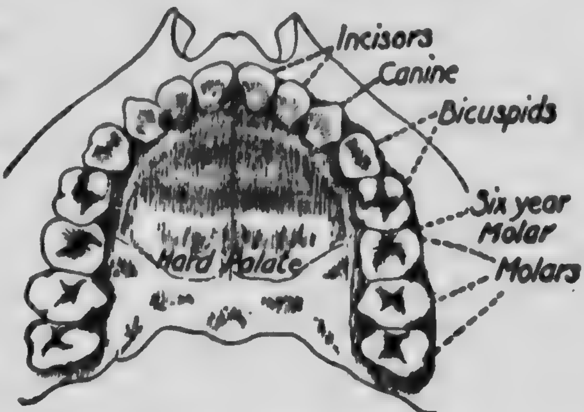


FIG. 9.—THE UPPER TEETH.

Care of the Teeth.—The teeth, when once they are fully grown, will never repair themselves. If a bone of the arm is broken, the two edges can be set in the proper position, and the bone will knit, or grow together again. If, on the other hand, a tooth is broken off or worn out, it will never repair itself. Teeth are liable to decay. The outside of the tooth, the enamel, is hard, but the inside is comparatively soft. As long as the enamel is in perfect condition, the tooth will remain sound, but if there is a crack in the enamel, decay is likely to start at the crack and enter the soft part inside. The tooth then decays rapidly until it is ruined. Even a very small hole in the enamel may result in a large cavity in the softer sub-

stance within. We should never pick the teeth with anything hard, such as needles or pins, because these are liable to scratch, and so crack, the enamel. For the same reason we should not crack nuts or other hard substances with the teeth. It is also harmful to the teeth to take extremely hot and cold foods or drinks in close succession.

Particles of food lodged between the teeth become decayed and help to decay the teeth in turn. It is well, therefore, to brush the teeth after each meal, and also at night, so as to remove any bits of food that might do injury if allowed to remain. To keep the teeth healthy and sound, it is necessary, in addition to brushing them, to remove, with a *soft* toothpick or thread, all bits of food which cling to them. When a tooth begins to decay, it should be attended to at once by a dentist; for if the small cavities are promptly filled, the tooth may perhaps be preserved for years, and much pain and expense be saved.

FIG. 10.—THE MOUTH.
Showing the opening into the throat.

Figure 10 shows the open mouth as it appears when we look within. Notice the palate and the uvula. By placing the tip of the tongue on the roof of the mouth just inside the upper teeth and drawing the tongue slowly backward over the roof of the mouth, we can discover the difference between the hard and soft portions of the palate.

Salivary Glands. — If some one says the word "lemon," our mouths are apt to water, as we think how sour the juice of the lemon is. The fluid which moistens the mouth, and whose flow is thus increased by the aid of the imagination, comes from the organs known as the **salivary glands**. The liquid produced is called **saliva**. There are three pairs of salivary glands. Those who have had the mumps can locate one of these pairs of glands without difficulty. These are the **parotid glands**, which are inflamed and swollen in that painful disease. They are situated just below and a little in front of the ears. There are two sali-

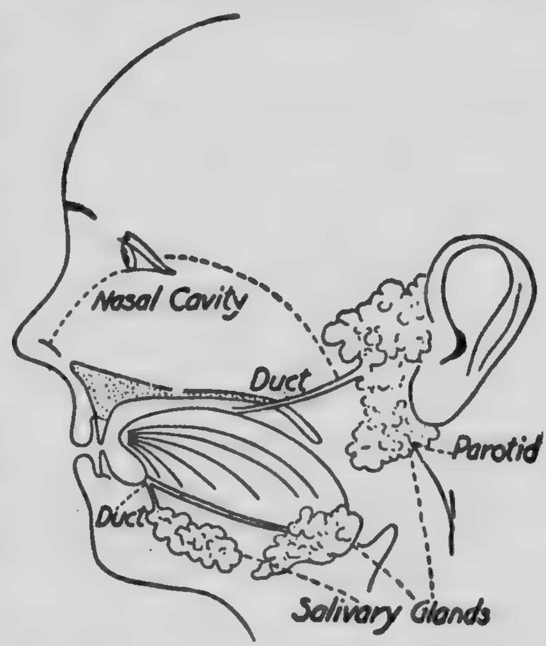


Fig. 11. — A Diagram of the Side of the Face.

Showing the position of the salivary glands and their ducts.

vary glands under the lower jaw and two more beneath the tongue. All these glands are connected with the mouth by little tubes, called **ducts**, which carry the saliva from the glands into the mouth. The saliva is poured out of the tubes whenever it is needed. Although the salivary glands are constantly sending out enough saliva to keep the mouth moist, the act of chewing stimulates the action of the glands so that the amount is largely increased.

Figure 11 shows the salivary glands on one side of the face, also the ducts that connect them with the mouth.

FOOD IN THE MOUTH AND THROAT

Need of Mastication. — After we have taken a bite of bread and butter, the first step towards its digestion is **chewing** or **mastication.** We chew our food to break it into small pieces so that the saliva may become thoroughly mixed with the food, and also that the digestive juices may afterwards do their work easily. The digestive juices in the stomach can act only on the outside of each piece of meat, and therefore the smaller the pieces, the shorter the time required to digest them.

Many a person suffers from dyspepsia as a result of the foolish habit of swallowing his food partly chewed. Rapid eating is injurious, since it forces the stomach to do work that belongs to the teeth. Very solid foods, like nuts or hard-boiled eggs, can be digested properly only after they are thoroughly chewed. Some foods, such as oatmeal and mushes of different kinds, do not

need much mastication, but solid food should not be swallowed until it is ground into a fine pulp.

Use of Saliva. — While the food is being chewed it is moistened by the saliva that is poured into the mouth. The saliva serves two different purposes.

1. *Saliva moistens the food and the mouth.* — If the mouth becomes dry, for any reason, we are very uncomfortable, and even talking is difficult. Sometimes, if we are frightened, the glands stop producing saliva entirely, and as a result we find it difficult to swallow. How impossible it is to swallow food that is not thoroughly moist may be comprehended by eating a cracker.

2. *Saliva begins the process of digestion.* — The water in the saliva dissolves some of the foods, like sugar, but this is not digestion proper. If, however, we chew a bit of bread for a few minutes, we find that it becomes a trifle sweet. The saliva ***changes the starch into sugar.*** The change begins as soon as the food is mixed with the saliva. It is the beginning of real digestion, although ordinarily the starch does not remain in the mouth long enough for much of it to be thus acted upon. If the food is acid (sour), as when it is mixed with vinegar, no change takes place in the mouth.

The amount of saliva in the mouth may be increased by chewing gum. In the case of an athlete who wishes to keep his mouth moist during exercise, gum chewing may be useful. Under ordinary circumstances, however, not only is the habit vulgar and impolite to the people about us, but the constantly stimulated action of the salivary glands is probably injurious.

Tonsils. — At the back of the mouth, as may be seen in Figure 10, there is a large opening leading to the throat. As soon as the food is chewed and moistened it is pushed back by the tongue through this opening. At each side of the opening may be seen a small rounded body called a **tonsil.** Sometimes when a person has taken cold, the tonsils become swollen, and a kind of sore throat called *tonsillitis* results. It is not known whether the tonsils have a special use or not.

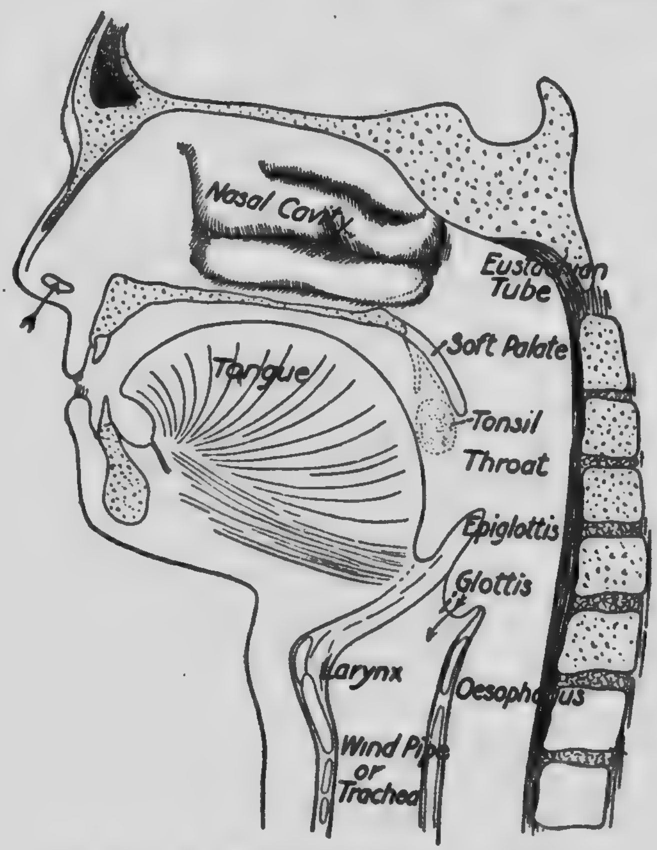


Fig. 12. — A Section through the Head. Showing the relation of mouth, throat, etc.

The Throat. — A cavity, called the **throat,** is situated just back of the mouth. Into this the food passes after being chewed. The upper part of the throat opens into the **nasal cavity,** and from there, by way of the nostrils, to the exterior. Thus both the mouth

and the nostrils are connected directly with the throat. Figure 12 shows this relation.

Two large tubes open downward from the throat. One, the **gullet** or **œsophagus**, extends to the stomach; the other, the **windpipe** or **trachea**, connects with the lungs. The windpipe is placed in front of the œsophagus, and it opens at the top, so that the air we breathe may pass into it readily. The opening is the **glottis**. If a particle of food drops into the windpipe, it causes violent coughing and sometimes choking. To keep food from entering the windpipe as it passes over the entrance on the way to the gullet, the windpipe is provided with an elastic lid, somewhat like soft India-rubber, which rests upon the opening.

When we are breathing, this lid, which is called the **epiglottis**, is lifted as in the illustration (Fig. 12); but as food passes from the mouth, the lid closes for the moment so as completely to cover the opening into the windpipe and allow the food to slid safely over. As soon as the food has passed, the lid flies up again, and the windpipe is open once more, ready for its regular work of carrying air to the lungs.

If we talk or laugh while our mouths are full of food, or while we are drinking, a bit of the food or water is liable to "go down the wrong way"; that is, we may have the epiglottis open for a breath just at the moment the food or water ought to pass over to the œsophagus. Some of it then drops into the windpipe instead of slipping over the top, and violent coughing results, until the foreign matter is coughed out.

Figure 12 shows a section of the head, indicating th shape of the throat and the openings into the mouth an nose, with the location of the windpipe and œsophagu Notice the epiglottis at the top of the windpipe.

Sore Throat. — Any soreness of the tonsils, the palat or the throat makes swallowing painful, and we say w have a sore throat. Sore throat, especially in the cas of children, should receive immediate attention. If a child feels any soreness when swallowing, his throa should be examined, and if there are whitish spots or the palate or the tonsils, a physician should be called at once, as the trouble may be serious.

Swallowing. — After the food reaches the throat it is rapidly swallowed. While food remains in the mouth we can control it, but the moment it enters the œsophagus it has passed beyond our control. If we should then discover that it was poison, we should be obliged to keep on swallowing just the same. The food is pushed through the œsophagus into the stomach by the muscles of the throat and œsophagus. It does not simply fall, but it is actually forced down. A person can swallow water even when he is standing on his head, and a horse, when he drinks, of course swallows the water upward.

FOOD IN THE STOMACH

The Stomach. — A few seconds after the food has entered the œsophagus it passes into a large cavity called the **stomach** (see Figs. 13 and 15). This is a chamber similar to a gourd in shape, lying just below the ribs and a little to the left side of the body. It is closed at

both ends by small folds or **valves**. The valve between the œsophagus and the stomach ordinarily prevents the food from going back into the œsophagus. Sometimes, however, when illness causes us to vomit or "throw up," the valve between the stomach and the œsophagus opens and allows the food to return to the mouth. The valve at the lower end, which connects with the tube called the intestine, prevents the food from leaving the stomach too soon. Figure 13 shows the stomach with its valves. The stomach itself is elastic, and will stretch so as to hold a large amount of food, but it shrinks again as soon as the food passes out. The stomach of an ordinary grown-up person can hold three pints of food very comfortably.

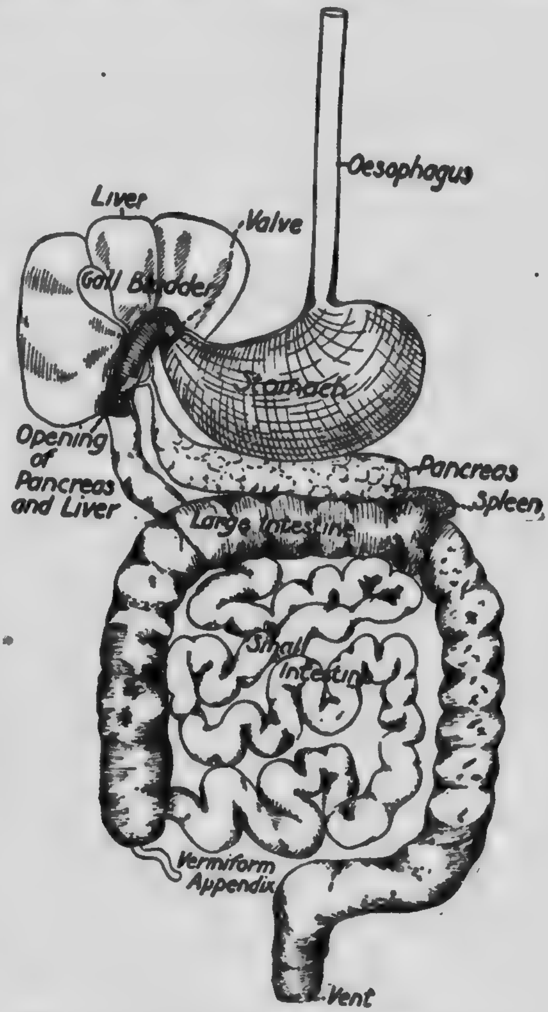


Fig. 13. — The Digestive Organs of the Abdomen.

The outer walls of the stomach consist principally o **muscular fibres** which run around it in various direc tions, some crosswise, some lengthwise, and some ob liquely. As these fibres contract and relax, they caus the stomach to undergo a variety of motions, which mi together the different foods inside and keep then moving around and around. As long as the food remains in the stomach it is thus kept in constant motion.

The inner lining of the stomach contains hundreds

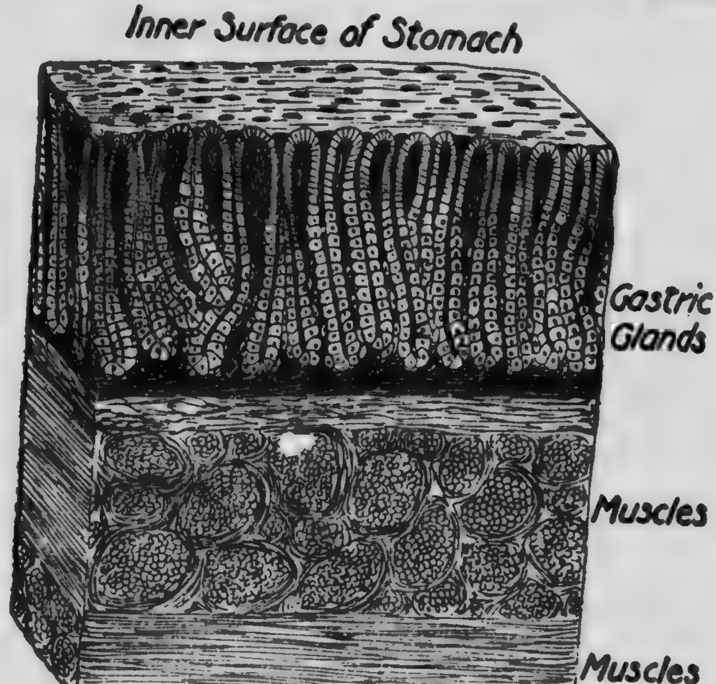


Fig. 14.—A Section of the Wall of the Stomach. Highly magnified.

of thousands of tiny **glands**. Each of these glands is shaped somewhat like a little bottle, with its mouth opening into the stomach, as shown in Figure 14. The

glands produce a liquid called **gastric juice**, which is poured out of their mouths into the stomach.

Action of the Gastric Juice. — As soon as the food enters the stomach, the glands begin to pour gastric juice upon it. At the same time the stomach, by contracting, begins to churn the food, and mix it with the gastric juice. In a short time the two are completely mixed, so that the gastric juice can begin to act upon the food and produce in it the changes that we call *digestion.*

Action on Starch. — When we chewed our mouthful of bread until it turned sweet, we found that the saliva had changed some of the starch in the bread to sugar. This digestive action of the saliva upon the starch is stopped as soon as the gastric juice begins to work upon the food. This is because the gastric juice is an *acid*, and we have already learned that the presence of anything sour prevents the action of the saliva upon starch. The starch, then, is not digested in the stomach, but it will be taken care of farther on.

Action on Meats. — A portion of the work of the gastric juice is to break the food into small parts. Meat is made up of a great number of tiny threads, called **muscle fibres**, which are glued together by a material that holds them in little bundles. The gastric juice dissolves this gluey material, and the fibres fall apart. Just as soon as the juice gets them separated it proceeds to act upon each one separately, changing it to a liquid form ready for the blood to take up, or, as we say, digesting it. We have noticed (see Fig. 2)

that the fat is in little sacs held together by a connec ing mass of threads. Both the sacs and the threa are dissolved by the gastric juice, so that the fat floa about freely in the stomach.

Action on Proteids. — It is also a portion of the wor of the gastric juice get the proteids read for the blood to use the building material the body. We found when we cooked th albumen of the egg an when we caught the glu ten of flour in musli cloth, that these proteid could not be dissolved i water. But, until these substances are in liquid form, they cannot be taken up by the blood. What the gastric juice does for the proteids is to change them in such a way as to make it possible for them to dissolve in the water that is in the stomach. After the gastric juice has done its work, a part of these glutens, albumens, and caseins become dissolved and are ready to enter the blood. Usually a part of the proteid food leaves the stomach undissolved and is changed to a liquid form later.

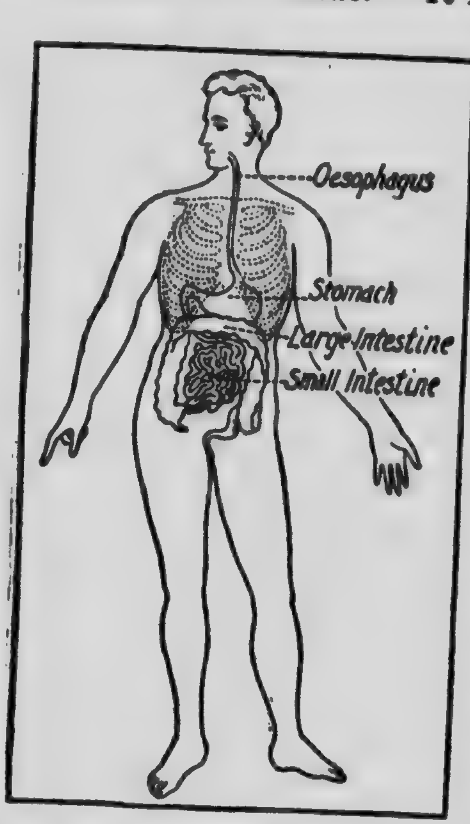


FIG. 15. — SHOWING THE LOCATION OF THE DIGESTIVE ORGANS.

Action on Milk. — After a hearty meal a baby often throws up a part of his milk in a curdled condition. This does not mean that the stomach is "sour," but simply that the child has overfilled his stomach. The milk ought to be curdled in the stomach, and if it did not curdle, it would mean that the stomach was out of order. The curdling has been caused by the gastric juice. The gastric juice in a baby's stomach curdles the milk more readily than that in the stomach of a grown person, but under all circumstances curdling is the first step in the healthful digestion of the milk. The curdled milk looks exactly as if it had soured.

We can see just how the curdling takes place by putting a teaspoonful of rennet or a rennet tablet (to be had at the druggist's) into a cup of milk warmed to about the temperature of the body (98½°). In the course of half an hour the milk will be curdled. Notice that the curd, which is casein, is a solid mass. In the stomach this curd is later dissolved again.

Chyme. — We swallow our food in the form of solid meat, solid bread, and liquid milk, and in a short time, from an hour and a half to three hours, it becomes quite changed. It is now a thick liquid. The fats, freed from their sacs, as we have seen, have been melted by the heat of the body; the meat has been divided into threads and partly dissolved; the sugars have been dissolved in the water; some of the starches have been turned to sugar and also dissolved; while the milk has been curdled and partly turned to liquid form again. These materials have been churned by the motions of

the stomach until they are thoroughly mixed together. They now form a gray, slimy mass called **chyme.**

Although we pay no attention to the matter and think little about it, our hearts continue their accustomed beating, hour after hour and day after day. And so it is with the stomach's work. We do nothing to supply the materials required by the body except to eat when we are hungry, and yet the wonderful work of digestion goes on, usually without inconvenience to us.

A Few Good Rules. — Though we cannot do much to help the stomach in the churning and digesting process, we may assist it by our manner of eating our food. If we are too thoughtless of the rights of the stomach, we are certain to receive our just punishment sooner or later in the form of indigestion and dyspepsia.

We can aid the stomach and preserve our own health by following a few simple rules.

We should eat slowly and be sure that the food is well chewed before it is swallowed. The habit of eating often between meals is very trying to the stomach, since it keeps the gastric glands in constant action. We should never eat a hearty meal when we are either very tired or very warm; it is wise to rest first. No hard work, either mental or physical, should be entered upon for at least half an hour after a hearty meal. This is the stomach's busiest time; we should help it as much as possible by keeping the rest of the body quiet.

We should be careful as to the quantity of water that we drink with our meals. Some water is required, but

the food should never be "washed down" with water. Nor is it well to drink much water immediately before a meal. Ice-water, if drunk at all, should be sipped slowly, so that as it passes down through the throat, it may be warmed more nearly to the temperature of the stomach.

FOOD IN THE INTESTINES

After the food has spent from one to two hours turning around and around in the stomach, the fold forming the valve or lid to the intestine opens and allows a small amount to pass out. The contents of the stomach thus from time to time pass into the intestines, until, at the end of three or four hours, the outlet relaxes and allows the remaining food to leave the stomach, even though some of the particles may still be quite solid. The stomach is now empty, and, after a rest, is ready for the next meal.

The Intestines. — The food which has passed through the opening at the lower and smaller end of the stomach enters the **intestines**, more commonly called the **bowels.** The intestines consist of a long tube, very much coiled, filling the larger part of the abdomen below the stomach, as is shown by Figures 13 and 15. The part which is connected with the stomach, or the **small intestine**, is from one to two inches in diameter, and about twenty feet long. The **large intestine** is about two and one half inches in diameter and five feet long.

The Liver. — We all have seen the liver of the ox or calf either exposed for sale at the market or on the breakfast table cooked with bacon. The human liver

resembles the ox liver very closely. It is of a dark red color, and lies a little above and at the right of the stomach. It is one of the largest organs in the body, weighing several pounds, and it is one of the most important. It produces a liquid called **bile**. The bile passes through a tube and empties into the intestines near the stomach. When digestion is not going on, the bile collects in a little sac at the lower side of the liver, known as the **gall bladder**. Figure 13 shows the liver, the gall bladder, and its tube or duct.

The Pancreas. — The **pancreas** is a long, somewhat thin gland, placed just below the stomach. This also produces a liquid secretion which passes through a tube and empties into the intestines. This liquid, which is called the **pancreatic fluid**, empties into the intestines with the bile. Thus the food from the stomach is mixed with the bile from the liver and the fluid from the pancreas almost as soon as it enters the intestines. Notice the pancreas, with its duct, as shown in Figure 13.

Use of the Liver. — Probably most of us know from experience how a person looks and feels when he is "bilious." The skin becomes a dull yellow, the eyes lose their sparkle, and the person seems to lose all his ambition without being sufficiently ill to be confined to his bed. The trouble is that the bile has ceased to pass freely from the liver. The bile aids the pancreatic fluid in its work of digestion, especially on fats, tends to prevent decomposition in the contents of the intestines, and aids in the regularity of the action

of the bowels. But the bile is, however, chiefly a ***waste product***, and it pours into the intestines partly as a way of disposing of itself. The liver has several duties to perform, but one important duty is to help to remove this waste material. When, for any reason, the bile cannot thus escape into the intestines, it passes back into the blood in the liver, and is then carried to all parts of the body, producing illness and turning the skin to a peculiar yellow. We then say we are bilious.

Changes in the Intestines. — As soon as the food enters the intestines it is mixed with the secretions from the liver and pancreas. Further changes are at once produced in the food, principally by the pancreatic fluid. The pancreatic juice acts upon all kinds of food in such a way as to make liquid those not already dissolved.

Starch. — We have learned that most of the starch escapes from the mouth without being turned into sugar by the saliva and passes into the stomach and out again to the intestines, still in the form of starch. But the pancreatic juice has just the same effect on starch that saliva has—it turns the starch to sugar. The pancreatic juice takes up and completes this work of changing starch into sugar. The sugar is then dissolved like all of the other food.

Proteids. — The pancreatic juice has the same effect upon the proteids as the gastric juice. It changes into a soluble form any proteids that may have passed into the intestines in solid state, whether they be the lean part of meat, the gluten of the wheat, or the casein of milk. The food in the intestines becomes more and more liquid.

Fats. — The last we knew of the fats they formed an oily mixture in the stomach, where the gastric juices could not act upon them. When they pass into the intestines the pancreatic juice begins to digest them. We have already seen that when we shake olive oil with water, the water separates the oil into minute drops that float, making the liquid look milky. In a somewhat similar way the pancreatic juice acts upon the fats as they pass along the intestines. It breaks the fat into millions of tiny drops which are mixed with the contents of the intestines, giving the whole mass a milky white appearance. The breaking up of the fat into drops is the *digestion of fat.* The fat is not actually dissolved like the sugar, but when it is broken up in this way the particles of fat are small enough to pass into the blood.

Chyle. — The food was swallowed as solid bread, meat, and potatoes, but now, after from two to four hours or more, it has become in the intestines a milk-white liquid, somewhat thicker than milk, but not so thick as molasses. It is called **chyle,** and it contains most of the foods, dissolved into liquid form. The food is now ready to be absorbed into the blood vessels.

THE DIGESTIBILITY OF FOODS

If our food were not digested, it would be of no more use to us than stones, for it could not be taken into the blood. People who have weak digestive organs suffer from lack of food, no matter how much they eat. For this reason the value of the food we eat depends as

much upon whether it is easily digested as upon the food substances that it contains.

Cheese, for example, contains a very large amount of valuable food, but it is so hard to digest that it is less useful than meat, which, although it contains less food than cheese, digests more easily. Beans are in some respects a more nourishing food than meat, but as they do not digest so easily, much of their value may be lost, passing away in the waste.

In choosing what we shall eat we should be careful not to load the stomach with food hard to digest. Although it is perfectly safe, if we are strong and well, to eat some foods that do not digest easily, we should not do so frequently. The following table will give us a little idea of some of the more easily digested foods and some of those less easily digested: —

Foods Easy to Digest	Foods Difficult to Digest
Milk	Fried foods
Bread	Beans and peas
Rice	Hard-boiled eggs
Raw oysters	Pork
Soft-boiled eggs	Veal
Boiled beef	Cheese
Mutton	
Boiled chicken	
Broiled meats	

Boiled or *broiled* foods are, in general, more quickly digested than those that are *roasted*, because boiling

softens the solid foods so that the digestive fluids can act upon them. *Fried* foods are more difficult to digest than the same foods cooked in any other way, since the frying is apt to soak the food with fat, which makes it difficult for the digestive juices to act.

HOW THE FOOD GETS INTO THE BLOOD

All this process has not yet put the food where it can be used to build up, repair, warm, and provide muscular power for the body. We are now ready for the final chapter of our story — how the digested food gets into the blood.

We have learned that by the time the food has been in the intestines from two to four hours it has all become digested and turned into *chyle*. The long intestinal tube which holds the chyle, is not loose in the body, but is held in position by a thin sheet. Such a sheet is called a *membrane*, and this particular one is the **mesentery**. It is folded many times and is wrapped around the intestines as shown in Figure 16. There are many *blood vessels* in the mesentery,

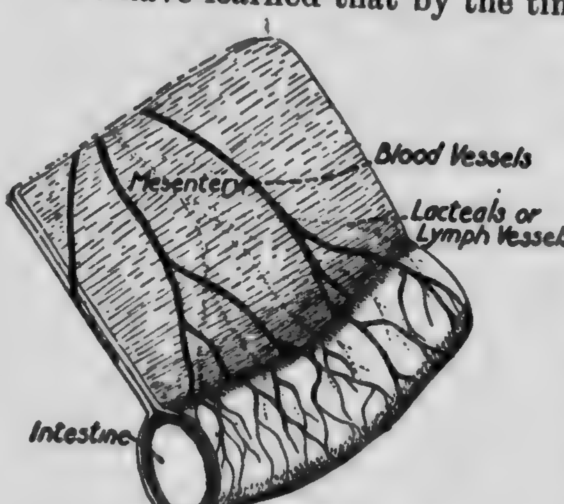


FIG. 16. — A BIT OF THE INTESTINE. Showing how it is held in position by the mesentery.

some of them carrying blood to the intestines, and others carrying the same blood away again. These blood vessels take away a large part of the digested food.

A bit of the intestinal wall is shown in Figure 17. The wall is rather thick and has two layers of muscles.

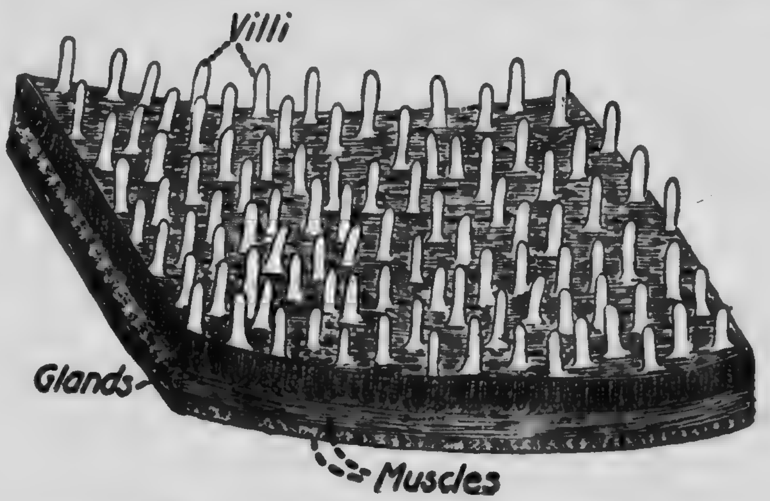


FIG. 17. — A BIT OF THE INTESTINE.
Showing the muscles, glands, and the numerous villi on its under surface. Moderately magnified.

The inside surface is covered with tiny projections, like little fingers, extending inward. They are called **villi.** Figure 17 shows some of the villi enlarged, so that we may see what they are like. Villi are really so very tiny that they can only just be seen with the naked eye. There are millions of them, so many that they line the whole inside of the intestines, giving it a soft, velvety surface.

Duties of the Villi. — The villi are very interesting to study, for they take the digested food out of the intestines and give it to the blood. Unlike the glands of

the stomach, of which we have learned, these villi have no opening into the intestines. Their walls, however, are so thin and so delicate that the dissolved food can pass through them readily. A single one of these little bodies, much magnified, is shown in Figure 18. It is covered on the outside with tiny cells, which form the **epithelium**. Inside there are a great many minute blood vessels. One blood vessel, the **artery**, brings blood into the villus, and another, the **vein**, takes it away. The artery brings the blood from the *heart*; the vein carries it away to the *liver*.

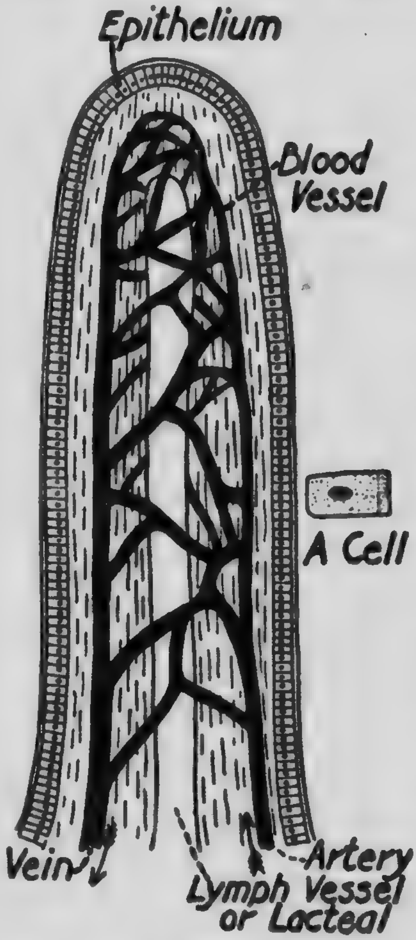


FIG. 18. — A SINGLE VILLUS. Highly magnified.

Just how the villi take the food and send it where it belongs is a particularly interesting chapter in our story of digestion. The white chyle moving along the intestines bathes the villi as it passes. Each little villus is constantly at work taking the digested food from the chyle as it comes along, leaving the undigested and waste matters. The dissolved sugars and albumens pass through the thin

membrane into the inside of the villus. Even the particles of fat are seized and passed into the inside. Thus as the food passes on through the intestines, more and more of it is taken up by villi, until most of the useful part has been removed. The way in which this food is taken into the intestines is illustrated in Figure 19. A bladder is tied tightly upon a tube and filled with water, and the whole is then lowered into a dish containing some sugar dissolved in water. It will be found after a little time that the water inside of the bladder has become sweet. The sugar has passed from the dish into the bladder. In much the same way the sugars and other foods pass from the intestines into the villi.

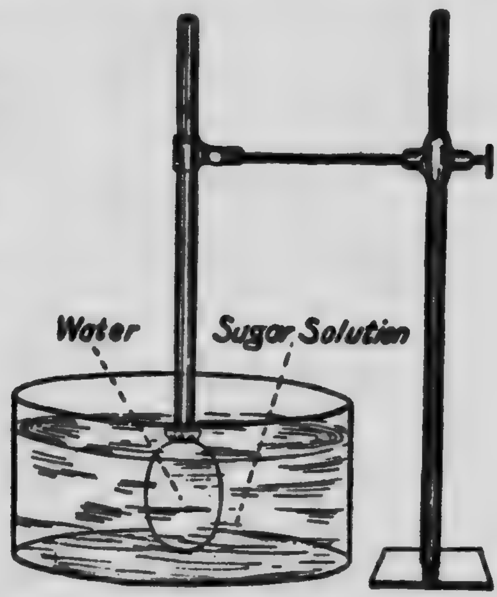


Fig. 19. — A simple device for showing how foods may pass through membranes, as they do when they enter the villus.

After the food gets into the villi it does not all go in the same direction. The *sugars*, *proteids*, *water*, and *salt* are taken out of the villi by their tiny blood vessels and are carried away in the blood to the liver. Of course the starch has already been turned to sugar by the digestive processes, so that all the foods go to the liver, except the fat.

The *fat* takes a different direction. It does not enter the blood vessels of the villi at all. The middle of the villus, as shown in Figure 18, is a clear space called a **lymph vessel** or **lacteal**. This opening or tube is made to receive the fat, and the little drops of fat pass directly into it. The vessels are called lacteals, which means milk holders, because the liquid fat with which they are filled is white like milk. After taking the fat from the intestines the lymph vessels empty it into larger, similar vessels and these empty into still larger ones which pass through the sheet of membrane surrounding the intestines. The large lacteals pass up through the chest, back of the heart, and empty the fat into one of the large blood vessels in the neck, so that all of the absorbed food material finally reaches the blood.

There are thus in the membrane shown in Figure 16 three sets of tubes: 1. Blood vessels bringing blood *to the intestines*. 2. Other blood vessels carrying the blood which has taken up food, *from the intestines* to the liver. 3. Lacteals carrying fat to the blood vessels in the neck.

UNDIGESTED PORTIONS OF THE FOOD

We have learned that the food passes from the stomach through the intestines. The material is kept moving by a contraction of the wall of the intestines. This contraction causes a gentle writhing motion of the intestines, which forces the food slowly along. The movement is somewhat similar to the wriggling of an earthworm as it tries to make its way along the surface of the ground. As the food mass passes on,

the villi take up more and more of what can serve the body as real food, together with much of the water. Finally, very little is left in the intestines except undigested refuse, together with excretions, like bile, which are of no further use. These are **waste materials**. As more and more of the water and dissolved food are absorbed, the waste materials become quite solid, until they pass out of the body at the vent. The bowels should get rid of the waste material every day. Regular habits in this respect are necessary for avoidance of discomfort and of sickness.

Now the story of food digestion is nearly completed. Let us recall briefly the history of our piece of bread and butter. It was carried to the mouth, and was bitten off and chewed by the teeth. With the aid of the saliva it was moistened and then swallowed. After a safe passage over the windpipe, the œsophagus carried it to the stomach. There it was thoroughly churned and mixed with gastric juice. Little by little it passed from the stomach into the intestines, was mingled with the bile and pancreatic juice, and then the digested part was taken up by the villi, leaving the waste materials to be discarded. As we shall see later, the food material finally reaches through the blood all the parts of the body which need it for growth or work.

QUESTIONS

1. What is meant by digestion?
2. Why is it necessary to digest food?
3. What are the parts of the mouth?
4. Of what parts does a tooth consist?
5. How many permanent teeth are there? What are their names?
6. What causes a tooth to decay?
7. What and where are the salivary glands?
8. What are the uses of saliva?
9. What prevents food from passing into the windpipe instead of the œsophagus?
10. How does the stomach digest the food?
11. What is the action of the gastric juices on meats? On proteids? On milk?
12. What is chyme?
13. What are the liver and the pancreas?
14. Of what use is the liver?
15. What changes are made in starch, proteids, and fats in the intestines?
16. What is chyle?
17. How does the food get into the blood?
18. If you chew finely a piece of meat, does saliva start its digestion? How would it be with bread?
19. Notice your method of swallowing, and see if you use your tongue.
20. What part of a lunch of bread and butter is digested in the mouth? What in the stomach? What in the intestines?
21. Since cheese is made of milk, why is it not a good food for babies?

CHAPTER III

FOOD HABITS AND COOKING

Unwise habits with regard to eating and drinking are probably the cause of more sickness than anything else. Indigestion, which is very common, may frequently be remedied more easily by changing the habits of eating and drinking than by taking medicine.

PROPER HABITS OF EATING

Suppose a company of boys from different parts of the world should come together for a picnic. Their lunch baskets would contain a good variety of what the owners would consider delicacies. The Canadian boy would probably have sandwiches and cake; the German, rye bread and sausages; the Chinese, some form of rice; the young Eskimo, a fish or a piece of seal. Each boy would be well nourished and satisfied, if only he had enough of his own kind of food. In other words, just what we eat is largely a matter of custom and climate.

We are mistaken if we think we *must* have certain kinds of food, for we can adapt ourselves to almost anything, provided it is nutritious and digestible. We have a very large variety of foods from which to choose, but it is wise to adapt the appetite to

what is conveniently obtained. We should particularly guard against allowing ourselves to be controlled wholly by taste, and we should not refuse to eat what is wholesome just because we fancy it is not quite to our liking. Substances with very strong taste, like mustard, for instance, we may properly refuse whenever they are distasteful, but there is no sensible reason for objecting to a dish of oatmeal; we can eat it, and learn to like it, if we will.

Cost. — People with small incomes are likely to live principally upon starchy foods, such as bread, rice, or potatoes, because these are comparatively cheap. But we cannot live upon starch and sugar alone. We must all of us have some proteids. If we will remember that we can get our proteids cheapest in beans and cheese, we shall be able to make better use of our money than by spending it all for starchy foods. A simple meal of bread, butter, milk, cheese or meat, and some vegetables, with perhaps a dessert of fruit or a simple pudding, is far better than a heavy dinner, with numerous courses. Some people make the mistake of having too many kinds of food at one meal, many of them highly seasoned. The pleasurable taste encourages us to eat more than the body requires, and the result is frequently a loss of healthy appetite. The man who spends a great deal of money for his food usually gets less pleasure from it than the one who lives upon plain foods varied by an occasional luxury.

Times for Eating. — Most people in this country eat three meals a day. In some countries four or five

meals are the rule, in others only two or even one. Whatever our habit in this regard, we should eat at certain specified times, so that the stomach may be called upon to work regularly, and may also have a chance to rest.

We frequently hear that candy is injurious, although we have learned that sugar is a useful food. The trouble is not with the candy, but with our abuse of it. If we have sweets in our possession, we are apt to be munching them all day long, keeping the stomach constantly at work. Moreover, the pleasant taste of the candy is likely to make us eat too much, so that we suffer from overeating. Some people, especially children, like to be eating all the time. This is very unjust to the stomach. Continuous good health is impossible unless the stomach and other digestive organs are given regular times to rest as well as to work.

Although breakfast is an important meal, it need not be a heavy one. Nor, on the other hand, ought we to make too light a meal of it. This error often leads to headache, faintness, and weakness before the noon meal. Fruit, oatmeal or some other cereal, and eggs, with bread, form an excellent breakfast. There is no better drink to go with it than water. Milk, chocolate or cocoa may also be taken, but we should remember that they are foods as well as drinks. The heartiest meal should be in the middle or at the close of the day, and should be followed by rest of at least an hour. A little food before going to sleep at night helps some to rest easily. A glass of hot milk taken just before a person

retires is frequently an excellent remedy for habitual wakefulness.

The Appetite as a Guide. — When we are in need of food we feel *hungry*, and when we need water we are *thirsty*. Hunger and thirst are, then, the guides given us by nature to indicate the want of food and water. If we treat them wisely, they guide us well, so long as we are in good health. But these appetites may be abused so that we cannot follow them safely. Some people, especially children, continue to eat anything that they happen to like particularly, even after their desire for food is gone, and they keep on drinking pleasant tasting liquids after the thirst is quenched. This is almost sure to do injury.

We should eat to satisfy the desire for food. One who continues eating after the body has taken sufficient nourishment is intemperate. Intemperance in eating or drinking, which means eating or drinking to gratify the *taste*, is probably the most common cause of ill health. It is always wise to stop as soon as the food ceases to be relished as much as it was when the meal began, instead of continuing to eat until there is a feeling of fulness in the stomach. If we make this a habit, we are not likely to suffer either from eating too little or too much.

Pleasure in Eating. — The old proverb, "Laugh and grow fat," is a saying with sound sense behind it. Good temper and merriment certainly aid digestion. Mealtimes should be among the pleasantest occasions of the day. There is no reason why we should not

enjoy partaking of the food, as well as take pleasure in the companionship of those who share our table. This enjoyment is lost in many homes, not only through making mealtimes the occasion for disputes, but by the unfortunate habit of "bolting" the food, which renders conversation an impossibility, and takes away all pleasure in the food itself.

Overeating, eating rich foods in great variety, and eating too frequently and rapidly, are the causes of most of the indigestion so generally suffered. Few maladies occasion more discomfort than indigestion. When one must always ask whether this or that article of food will agree with him or give him pain, a great part of his pleasure in life is gone, and it is no wonder that he becomes soured in disposition, as so many dyspeptics do. Children usually, however, have strong digestive organs, and the boy or girl who will eat wholesome food regularly and slowly will probably have good digestion throughout life.

THE HABIT OF USING ALCOHOL

Alcohol and Digestion. — Some people try to stimulate digestion in various ways, most commonly by the use of alcoholic drinks, especially wine. Whether in certain cases of impaired digestion alcohol may be of some use in stimulating the production of digestive juices is a question for the physician; certainly for a boy or girl or any healthy person to use it for this purpose is unwise. As an aid to digestion it should be regarded as a drug, and be used, if at all, only under medical direction.

Many persons use alcoholic drinks for this or som other purpose until they get into such condition tha they cannot properly digest food without using win or alcohol in some form, to stimulate the weakenec digestive powers. They have become like a horse that will not travel without a whip. The continued use of the alcohol is very likely to injure the stomach so that finally proper digestion is impossible even with its aid. The boy or girl who wishes to grow up strong and vigorous, with healthy digestive organs, will let alcoholic drinks entirely alone.

The Appetite for Alcohol. — There is one characteristic of all alcoholic drinks that makes them very dangerous. If a person eats ordinary foods, such as sugars and starches, he may sometimes eat too much; but this does not develop a desire for larger amounts of the food. We may eat enough candy to make us ill, but it does not increase our desire for candy. On the contrary, it sometimes even causes us to lose all fondness for sweets, at least for a time. But alcohol frequently acts in a different way, its use creating a desire for more.

The first glass a boy takes is generally not pleasing; but if he continues to use alcoholic drinks, after a little he comes to enjoy the taste and the effect, and in time he finds that he has a *craving* for it, and feels a certain lack if this craving is not satisfied. Whereas at first a small amount of the alcoholic drink was all he wanted, he soon becomes accustomed to this, and almost without knowing it he takes a little more. This, later, fails to

satisfy him, and, not realizing how serious a matter it is, he increases the amount of alcohol he uses, sometimes by drinking larger amounts of weaker liquors, and sometimes by taking stronger ones. And so the appetite grows until he finds it almost impossible to conquer it. In other words, instead of being a free man he has become a slave, and frequently a willing slave, for the use of alcohol constantly and in large amounts ordinarily destroys all desire to live a healthful, clean life.

In most cases the boy who drinks does not know that the appetite is growing until it has become so strongly fixed as to do him great injury. In just this fact lies the greatest danger, for if he could realize how he is coming under the influence of the unfortunate habit, he would break it before it mastered him, and before it destroyed his will power. When that is gone the best of the boy is lost.

Now, it is true that some people use small amounts of alcohol without becoming mastered by the habit. But it is equally true with others that the small amount of alcohol taken at first leads to the development of an appetite which in time completely masters them. Habitual drunkards are made out of boys and girls who did not intend to use alcohol enough to injure them. Unfortunately, even science has no way of telling which people can drink alcohol without falling under the sway of its appetite. Strong people, as well as weak, give way to it. The moment a person begins to use alcoholic drinks, even in a mild way, he places himself in the class of people from whom drunkards

may be made. The only safe way is to keep as far from the danger as possible, by letting drink absolutely alone.

Intemperance in Eating and Drinking. — Although alcohol is likely to do us more harm than any other kind of drink or any food, still we should be careful to *avoid all forms of overindulgence.* We may injure ourselves by eating too much candy or any other enjoyable food. We should make up our minds to be moderate in all our eating and drinking, for in this way only can we insure the strong, healthful growth of the body, and only thus shall we be able to do our share of the world's work, unhindered by any form of ill health.

PURPOSES OF COOKING

No one who, on entering the house tired and hungry after a half day at school, has been greeted with the appetizing odors coming from the kitchen, need be told that cooking has its advantages. We eat very few foods without cooking, except milk, a few vegetables, and fruits. Most foods are not considered fit to eat until they are cooked.

There are three purposes in cooking food.

1. *Cooking develops a flavor.* — We have only to notice the difference in taste between raw beefsteak and the same steak broiled and ready for the table to comprehend how cooking improves the flavor. It is true that cooking injures the flavor of certain fruits, such as strawberries, but it improves the taste of all meats and most vegetables.

2. *Cooking makes food easier to digest.* — The cooking of vegetable foods is usually necessary to enable us to digest them. Potatoes, for example, contain large amounts of starch; but it is shut up in little sacs of a kind of woody substance, as shown in Figure 5, and so long as the starch is in these sacs the digestive juices cannot get at it. The juices have little or no power to dissolve the sacs, and consequently raw potato cannot be digested. Cooking softens the woody sacs and sets the starch free. Moreover, it causes the starch grains themselves to burst and when burst they are more easily digested. We should remember that all starchy foods should be well cooked before they are eaten. The cooking of meats is not of great importance so far as mere ease of digestion is concerned. In fact, most meats are more easily digested if they are not cooked too much.

3. *Cooking removes danger from parasites.* — Some of our foods contain minute living animals, called **parasites**. Some of these, harmless in themselves, throw off products which are poisonous; others are themselves dangerous, and might do us considerable injury if swallowed alive. Pork, especially, sometimes contains large numbers of very small living worms, which, if taken into our bodies alive, are likely to cause serious disease, perhaps death. Pork has occasionally another parasite which may develop in the human stomach into a tapeworm several feet long. Heat kills the parasites, and pork, including ham, should therefore always be thoroughly cooked. Beef and mutton are less likely to contain these parasites, but neither should

be eaten uncooked. We have already learned that milk is frequently cooked, or *sterilized* as we say, to destroy any disease bacteria it may contain.

PRINCIPLES OF COOKING

The ambitious girl who takes pride in her ability to make an appetizing cake or to prepare a dinner does not need to be taught the effect of cooking on the various articles of food. Neither does the boy who goes camping in the summer and gets his own meals. Nevertheless, there are certain principles underlying cooking that we cannot learn over stove or camp-fire, but which we can easily understand. We have already found by testing the white of an egg that cooking coagulates albumen. We know, too, from boiling starch, that cooking changes starch foods into pulpy masses. Experience in the kitchen has shown us that vegetables are softened by cooking, and that fatty substances are melted or made liquid by the same process. In general, cooking softens foods so that they are made easier to chew and to digest. Another general principle which should be borne in mind in all cooking, is that proteids are coagulated by heat. This is especially important as related to beef tea and soups.

Beef Tea. — If raw beef is cut fine and soaked in water, a part of the nutritious material is dissolved, and the liquid is good food as it stands. But if, after the beef has been soaked, the liquid is boiled, all of the dissolved material is coagulated and appears as a brownish scum. This can be separated from the

rest by straining the liquid through a cloth. *Beef tea* is usually strained, the liquid being used and the scum thrown away. Such tea is pleasant to the taste, but after the scum has been taken off it contains almost no food. Nothing is left except the salts and flavors. These are, however, frequently of use to invalids. The salts and flavors have a stimulating action on the digestive glands, and thus assist in giving the sick person an appetite, so that he can take, and more easily digest, real food. Beef tea is therefore of use in sickness or for persons with weak digestion; but it should always, if possible, be taken together with something more substantial. If the tea were made of finely minced beef put into cold water and very slowly heated, until quite hot, but *without boiling*, it would be very nutritious, for it would then contain the food material, which is not all coagulated except when actually boiled.

Soups and Stews. — The straining out of the food applies also to the making of *soups* from meats and vegetables. The heat of boiling produces coagulation, and the clear liquid, which is strained off and served as the soup, contains little more than the salts and flavors. Soups are not, however, usually regarded as foods. They are served at the beginning of a meal as a slight stimulant to digestion. *Stews*, on the other hand, the whole cooked mass of which is eaten, are nourishing and useful foods. Though the proteid has been coagulated, this does not injure the stew as a food, since the coagulated material as well as the liquid is eaten.

METHODS OF COOKING

If some one should ask us how our mothers cook, the most natural answer would be, "In all sorts of ways." The answer would be correct in a certain sense, and yet all kinds of cooking may be included under the four heads of *boiling*, *baking*, *broiling*, and *frying*.

We put a cover on top of the kettle of boiling meat to hinder the escape of the steam and the odor. Similarly, whenever we can, we put a cover or crust around the object which is being cooked, to keep all the food material and flavors inside. This may be done by heating the object very hot when the cooking begins. Thus a crust is formed on the outside of the loaf of baking bread. The high heat forms a similar protective coat around the meat by hardening the proteid and so keeping the juices and flavors within.

Boiling. — Boiling is one of the commonest and best methods of cooking, although it does not produce the finest flavors. The article is cooked or boiled in water. One of the standing rules of housekeeping is, "If you want to have the richness *in the liquid*, you must put the article into cold water and heat slowly; if you want the richness *in the article itself*, it must be put into boiling water." So vegetables must be dropped into boiling water, while meat for stews should be put upon the stove in cold water. If the meat is placed in boiling water, a coat is formed on the outside at once, and then the whole may be allowed

to simmer over the fire for a long time without much further loss. Meat cooked thus will retain its juices and have an excellent flavor, while the water in which it is cooked will contain practically nothing of value. The liquid of the stew, on the other hand, is to be eaten with the solid matter, so the meat should be placed in cold water and then allowed to simmer slowly, in order that the liquid may contain part of the food. Stewing is an economical method of cooking, since in this way nothing of the original food is lost.

Baking or Roasting. — Baking and roasting are two good methods of cooking which differ slightly from each other, but are similar in principle. The food is cooked in hot air, either in an oven or over a hot fire. When the food is cooked over the open fire we call it *roasting;* when cooked in an oven, we commonly speak of it as *baking*, or, in the case of meats, we call it *roasting.* As the heat causes the liquid juices, especially of meat, to ooze to the surface, it is best to prevent the loss of these juices as far as possible. This is done, as in boiling, by heating the meat very hot at the beginning, so that a crust may be formed. The flavor and richness of the meat are much improved by pouring over it, say once in every fifteen minutes, the liquids which ooze out, a process called *basting.* If there is not sufficient liquid for this purpose, melted butter or suet, or even salt water is used. In baking bread and cake it is also desirable to use high heat at the start.

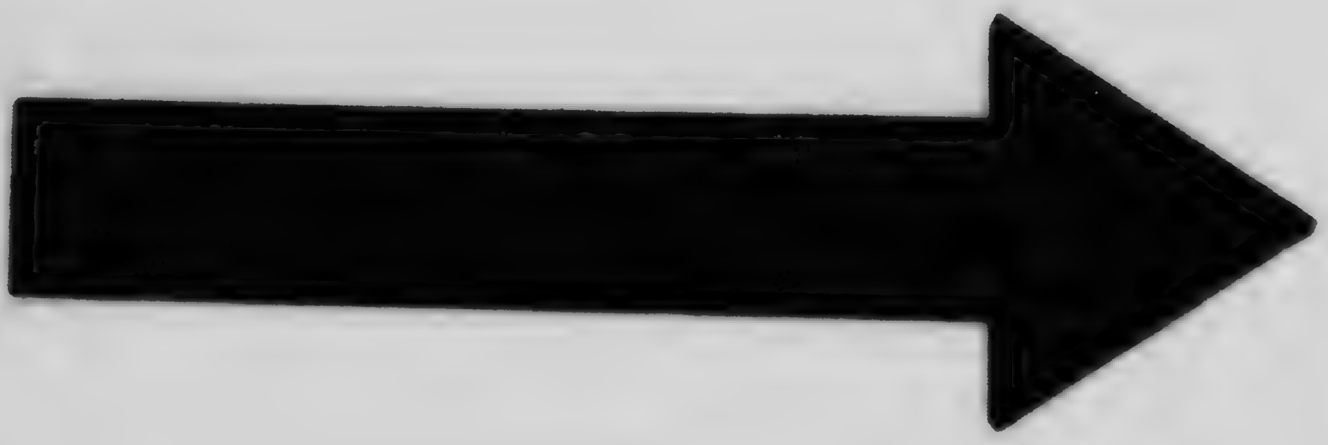
Broiling. — One of the quickest and most desirable ways of cooking is broiling. Especial care should be taken to begin the cooking over a very hot fire in order that the surface of the meat may be quickly seared over, and the juices thus kept in it.

Frying. — Frying is a method of cooking very common, but not wholesome. As the food is cooked in hot fat, butter, suet, or olive oil, it is apt to become saturated with the fat. While fat of itself is nutritious, food soaked in it is very difficult to digest. To fry with the least injury to the food, there should be an abundance of fat, and it should be very hot. The high heat, as in other methods of cooking, forms a crust on the outside, which prevents, in considerable measure, the fat from getting into the food.

Yeast and Baking Powder. — To make bread we mix flour with water, or milk, add **yeast**, and set the mixture in a warm place to "rise." The yeast grows in the bread, producing a very small amount of alcohol and a gas called carbon dioxide. The bubbles of gas appear in the dough, causing it to rise up like a sponge. In baking, both the alcohol and the gas are driven off by the heat, but the bread is filled with the little holes which were previously occupied by the carbon dioxide. This makes the bread "light," and easy to masticate and digest. Similar bubbles are made in cake and biscuit by putting **baking powder** into the dough. As baking powder produces the gas very quickly, it is adapted to rapid baking. To develop the necessary gas with yeast requires that the dough rise for several hours.

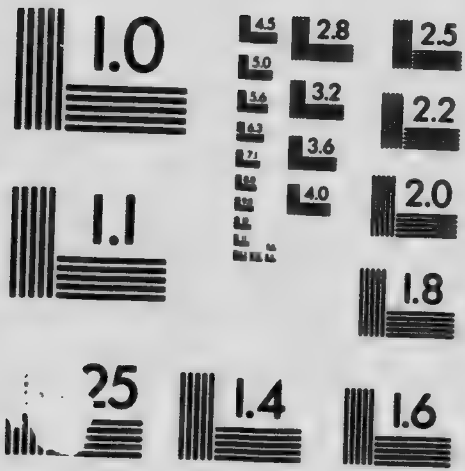
QUESTIONS

1. Why does an Eskimo eat fish and seal, while a Chinaman eats rice?
2. What facts should be considered in choosing our diet?
3. What kinds of food should be used together?
4. When should we eat?
5. Is food with a pleasant taste more useful to the body than food without flavor? Why?
6. How can we best enjoy our food?
7. Why is rapid eating unwise?
8. What effect has alcohol on digestion?
9. How is an appetite for alcohol developed?
10. What are the purposes of cooking?
11. How does cooking make a potato easier to digest?
12. What does cooking generally do to food?
13. Why is a stew nutritious while beef tea is only a stimulant?
14. What are the three methods of cooking?
15. How is cooking done by boiling?
16. How is food cooked by baking?
17. Why is fried food apt to be indigestible?
18. What foods may properly be eaten without cooking?
19. What do yeast and baking powder do to food?
20. Why is plain food more healthful than rich food?



MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



CHAPTER IV

CIRCULATION

EVERY house in a large city is supplied with water from faucets. The water is carried to the house by pipes laid in the ground, and the pipes come from a reservoir which supplies the whole city. In many places a large pump near the reservoir forces the water into the pipes. If the pump stops working, the water throughout the city ceases to run.

We have seen how the food which we have eaten gets into the blood. This food is needed in all parts of the body. It is carried to the arms, the head, and the various organs by the **blood vessels**, very much as the city is supplied with water by the water pipes. The blood vessels are tubes running through the body, dividing into branches, and these again into smaller branches, so that every organ of the body, no matter how small it may be, has at least one. The heart acts as the pumping station, and by it the blood is kept in constant motion.

THE BLOOD

Let us see what this liquid is which flows so constantly through the blood vessels. We already know that it contains the part of the food we have eaten

which has been dissolved and absorbed from the intestines. But it has in it other materials besides. The blood that oozes from the finger when we have a cut looks bright red. If, however, we look at it through a microscope, we find that the liquid itself is almost as clear as water. In fact, the liquid part of the blood, called **blood plasma**, is largely water, although several substances are dissolved in it. The red color is produced by millions of little red bodies floating about in the liquid. These minute bodies are called **corpuscles.**

Red Corpuscles. — The most prominent of the solid bodies in the blood are the **red corpuscles.** These are

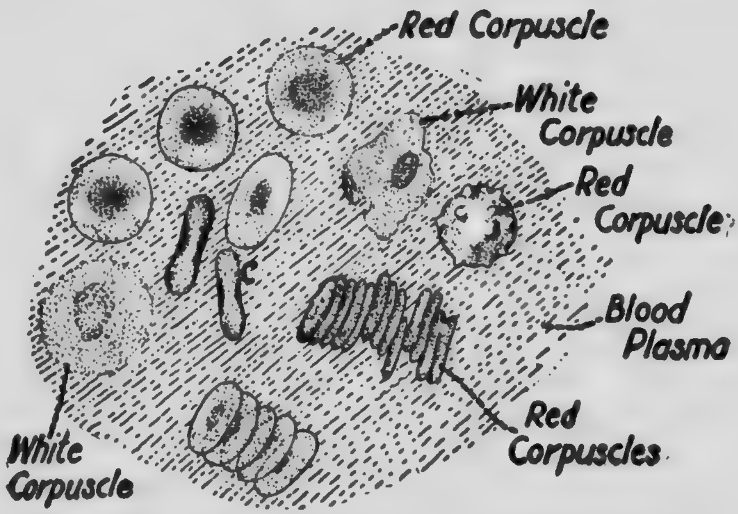


Fig. 20. — A Little Blood, as it appears under a Microscope.

shown in Figure 20. They are small, thin disks, circular in shape. As may be seen from *C*, they are slightly thinner in the centre than at the edge. They are very small, only about $\frac{1}{3200}$ of an inch in diameter, and

consequently they are invisible except through a microscope. They are present in the blood in immense numbers, there being some 5,000,000 of them in a very small drop. Each red corpuscle contains a red substance called **hæmoglobin**. The important work performed by the red corpuscles we shall study in a later chapter.

White Corpuscles. — The **white corpuscles** act as the street-cleaners in the body. They are fewer in number than the red corpuscles. They are transparent, and of a slightly bluish appearance. They have no definite shape, and in fact they are changing shape constantly, although they are most commonly somewhat spherical, as shown in Figure 20. All the corpuscles, both white and red, flow through the blood vessels with the blood. The red corpuscles can go only where the blood carries them; but the white corpuscles sometimes crawl out of the blood vessels entirely, pushing their way through the walls. They then travel around independently among the muscles and various parts of the body. There they catch and carry off any minute irritating substances which might produce trouble and perhaps disease, if allowed to remain. Thus the white corpuscles of the blood are believed to have a very important part in warding off certain diseases.

WHAT MAKES THE BLOOD FLOW

The Heart. — The **heart** is situated in the chest a little below the neck and slightly on the left side, where, as we know, its beating may be felt. In an adult, the heart is about the size of a man's fist, and is somewhat

pear-shaped, as shown in Figure 21. When in the natural position, the apex, or small end, is turned downward and a little to the left. As long as a person lives, his heart continues to pump the blood through his blood vessels, so that the motion of the blood and of the heart never ceases. Like a pump, the heart has tubes entering it on one side bringing the blood in, and others on the opposite side carrying the blood away from it. The blood vessels bringing blood to the heart are called **veins**; those carrying it away are called **arteries.** In Figure 22 (facing p. 84) the arteries are colored red, the veins, blue.

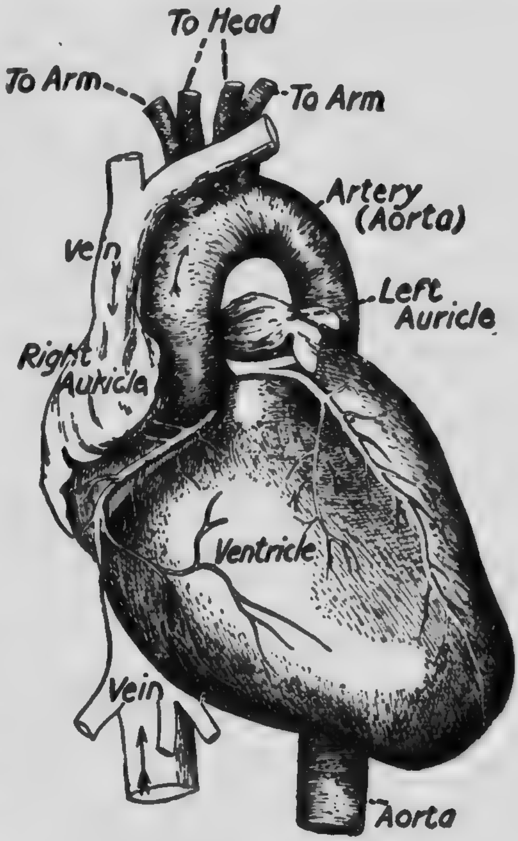


Fig. 21. — The Heart.
Showing the veins and arteries connected with it.

If we cut open the heart of some large animal, such as a sheep or an ox, we shall find that, like the human heart, it contains four cavities, as shown in Figures 23 and 24. The two cavities on the right side, called the **right auricle** and **right ventricle,**

are connected with each other. The two on the other side, the **left auricle** and the **left ventricle**, are also connected with each other. There is no connection between the two sides of the heart; the blood cannot flow directly from one side to the other.

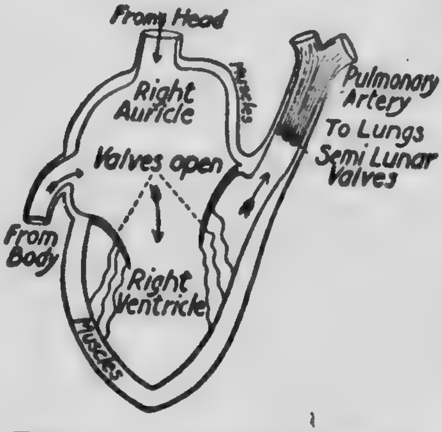


FIG. 23. — THE RIGHT SIDE OF THE HEART.

As the heart beats, blood which has just completed the round of the body, and is full of impurities which it has gathered, flows into the right auricle through the large veins from the head and body, indicated in Figure 23, and fills both the right auricle and the right ventricle. Then the heart contracts, that is, the muscles of the walls press the blood out, as we squeeze the juice out of a lemon by closing the hand tightly about it. When the heart contracts, the blood forces its way into the **pulmonary artery**, shown in Figure 23. The pulmonary artery carries it to the lungs to be purified.

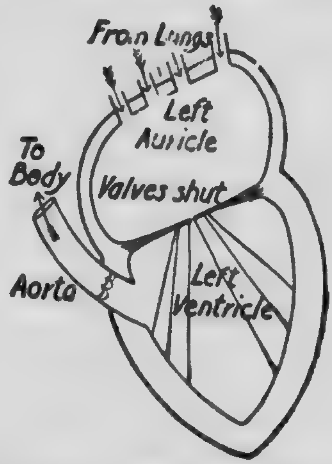


FIG. 24. — THE LEFT SIDE OF THE HEART.

From the lungs the purified blood comes back to the heart again, this time by veins which send it into the upper of the two chambers at

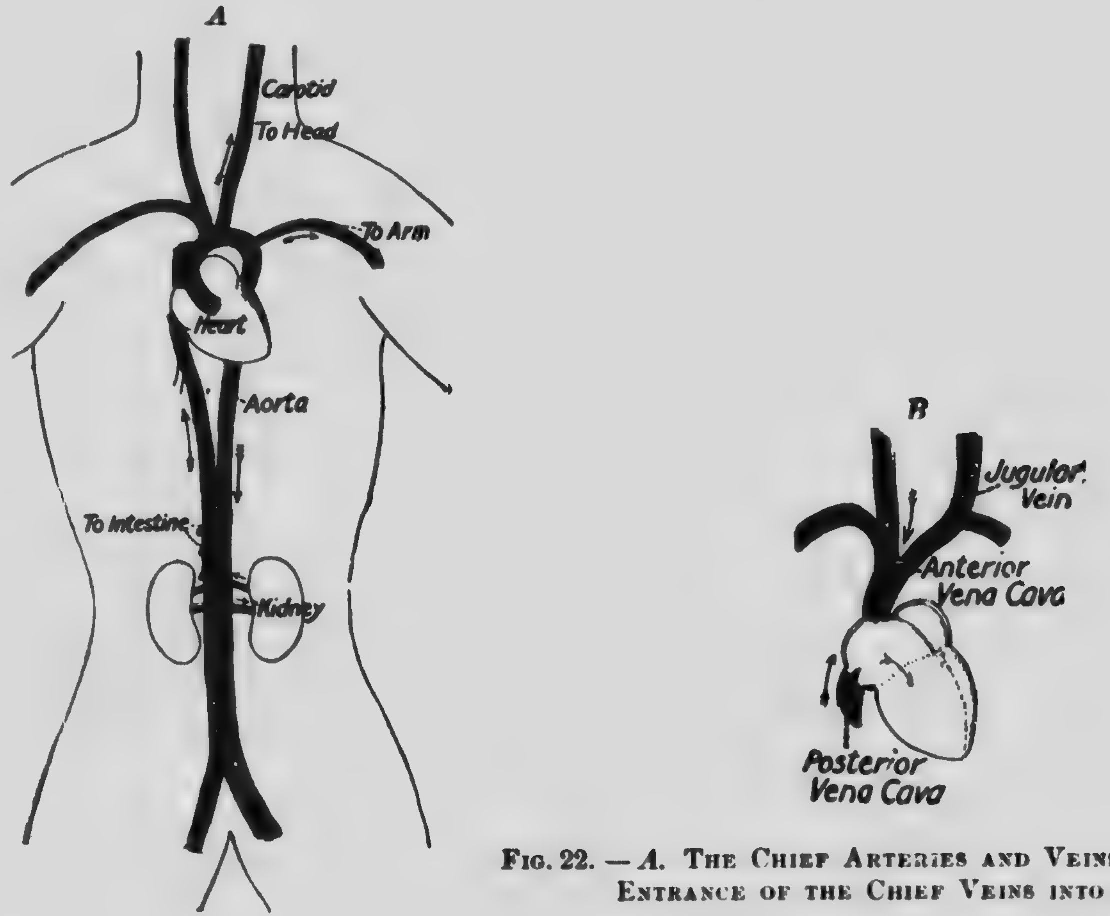


FIG. 22. — *A*. THE CHIEF ARTERIES AND VEINS. *B*. SHOWING THE ENTRANCE OF THE CHIEF VEINS INTO THE HEART.

the left side of the heart, that is, into the left auricle; thence it goes to the left ventricle, as shown in Figure 24, and by this it is sent through the large artery (the **aorta**, Figs. 22 and 24) in all directions through the body. Thus every time the heart beats, one side of it takes blood in from the head and body, sending it to the lungs, and at the same time the other side of the heart takes blood in from the lungs and sends it out through the body.

In order to keep the blood flowing in the right direction and to prevent its flowing backward, the heart contains several valves. These are folds inside the heart. When open, as in Figure 23, they allow blood to pass freely in the direction indicated by the arrow; when lifted, as in Figure 24, they completely close the opening between the auricle and the ventricle and prevent blood from being forced back into the auricle when the ventricle contracts. As soon as the heart relaxes, they open again and allow the ventricle to fill up once more. There are also some valves called **semilunar valves** (shown in Fig. 23), which in a similar way prevent blood from flowing back from the artery into the heart.

The Beating of the Heart. — The heart never seems to get tired. All day and all night our whole lives through it keeps at its work of pumping the blood. The heart of a grown person beats about seventy times a minute, that of a child somewhat faster. It spends about three tenths of a second in beating, and then rests for four tenths of a second. In this way it really works less time than it rests, only instead of working in the daytime and resting at night, like the body in

general, it does a bit of its work and then rests. In this way it is able to keep beating without becoming worn out. When we are in good health the heart beat is strong; it weakens when we are ill.

One reason why the use of tobacco and alcohol is injurious is that these substances are likely to weaken the proper action of the heart. Both alcohol and tobacco, if used by young people, are very likely to cause heart difficulties. Nearly every boy knows, from his own observation, that neither the habitual smoker nor the youth who uses alcohol wins in the athletic contest.

The Pulse. — When a stone is thrown into a pond, the water is disturbed in the form of a circular wave which grows larger and larger, but all the time lessens in height, until it disappears. A somewhat similar effect is produced by the heart as it forces the blood into the arteries. The wave of pressure produced by the heart is felt all through the arteries, though it is less strong the farther it is from the heart. The wave causes a slight swelling of the arteries as the blood passes. The artery at the wrist is so near the surface that we can feel the wave, known as the **pulse**.

The pulse can be found in any of the arteries where they are near the surface; but as most of them are deep in the muscles, there are few places where we can feel the throbbing. The usual place for testing the pulse beat is at the wrist, but it can be felt at the neck, just under the lower jaw, and also at the temples. By feeling of the pulse the physician can obtain considerable information regarding the general condition of the patient's health.

BLOOD VESSELS

Arteries. — When the blood is forced out of the heart from the left ventricle it passes into the large artery shown as red in Figure 22. This serves as the main artery to supply the body. The artery bends over to the left and runs down the body, giving off several branches on its way. The first branches extend to the head and the arms, while others lead to the stomach and the intestines, and still others run down into the legs. This main artery thus supplies blood to all parts of the body, just as the water main furnishes water for every house. The farther the branching arteries are from the heart the smaller they become, until finally each is divided into thousands of minute tubes which enter every organ of the body.

Capillaries. — If we should follow up a single one of the minute branches of an artery, we should find that it ends in a set of even smaller tubes, like those shown in Figure 25. These are called **capillaries**. The capillaries are too small to be seen except with the aid of a microscope. They divide into many branches which come together in a somewhat irregular manner, differing in different localities, as shown in the figure. The blood flows from the small arteries into these capillaries, and it is here that the food materials held in solution are given up to the living parts of the body. Every part of the body is filled with capillaries, and through them each part gets its share of food from the blood.

We must remember that the blood, whether in the

arteries, or in the veins, or in the tiny capillaries, is always flowing in closed tubes. It never empties into the tissues, but passes to them through the delicate walls of the capillaries. Only the liquid part passes through, the corpuscles remaining in the blood vessels.

Veins. — A four-track railroad usually has two tracks for the trains, say from Chicago, and two for the trains going to Chicago. Let us say that the two tracks from the railroad centre represent the arteries which take the blood away from the heart. After its journey through smaller arteries or branch roads, and through the capillaries or switches where it leaves the food, the blood is ready to go back to the heart on the return tracks.

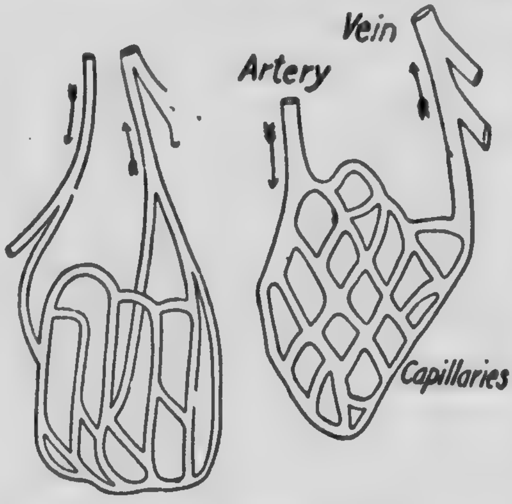


FIG. 25. — CAPILLARIES.
Showing their method of branching. The figure on the right shows capillaries in the skin; on the left, capillaries in the muscles.

The little capillary branches combine into larger tubes or blood vessels called **veins**, which carry the blood back to the heart. The veins in turn combine, and the nearer they get to the heart the larger and the fewer in number they become. Finally they unite into two large veins, which pour all the blood back into the heart. Figure 22 B shows the connection of the heart

with these veins. With the next beat after the blood has been poured into the heart from the veins, it is pumped out again, and sent once more on its circuit to the lungs and around the body. The general arrangement of the heart, arteries, capillaries, and veins may be understood from Figure 26.

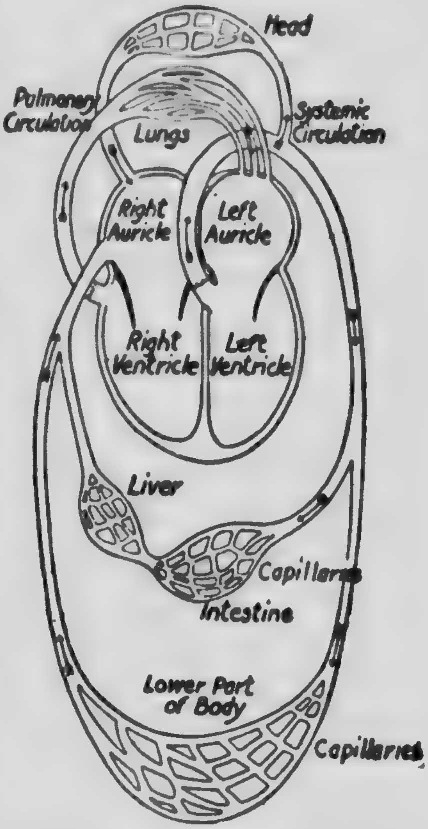


Fig. 26.—A Diagram showing the General Circulation. The blood flows in the direction of the arrows.

The whole process of **circulation**, as it is called, is like what would happen if all the water that flows from our water faucets, and, after being used, is thrown into our sinks, were carried back to the reservoirs, there to be thoroughly purified, and sent out once more to the various houses.

All of the arteries, except those going to the lungs, carry *pure blood*, while the veins, except those coming from the lungs, carry *impure blood*. The pure blood becomes impure as it takes up waste material in the capillaries, as explained in a later chapter.

The arteries are embedded deeply in the flesh; the veins are nearer the surface. A cut in the flesh is almost sure to sever one or more small veins, but

unless it is very deep the arteries will not be injured. The blue lines appearing on the back of the hand, when the hand is allowed to hang downward, show the positions of the veins.

HOW THE BLOOD FLOWS

Most of us are familiar with some form of pump. We have noticed that the water flows out of the spout in spurts; but if it is allowed to pass for some distance through a trough or along the ground, it flows as steadily as if it had come from the pump in a continuous stream. The movement of the blood in our bodies is similar. The heart sends the blood into the main artery in spurts, pumping it with force, just as the pump forces water into the trough. As the blood goes farther and farther from the heart, it flows along more quietly, until, by the time it has passed through the capillaries and is on the home trip through the veins, the spurting has ceased entirely.

When the heart beats, it forces more blood into the arteries than can easily flow through them. Instead of being stiff, however, like iron water pipes, the arteries are elastic like India-rubber. The blood flowing into them in spurts causes the arteries to stretch, so that it flows more smoothly than it would if flowing in similar spurts through iron pipes.

Bleeding. — The blood is pumped into the arteries with so much force that it flows out very rapidly in strong jets if an artery is cut or broken. The bleeding must be stopped quickly, or the person may bleed

to death. The veins, on the other hand, do not become stretched, since the blood flows in them with less force. If a vein is cut, the bleeding is not so rapid as from a severed artery, and it is not so dangerous. But in any case the bleeding must be stopped, for even a small wound in a vein would cause death if the flow of blood were not checked.

Fig. 27. — Showing the Main Artery of the Arm.

Many of the most common accidents to which we are liable produce bleeding. If the wound is only a slight break or a cut in the skin, the bleeding will not be serious. We need only to bring the edges together and bind the cut or other wound somewhat tightly with a cloth or a bit of adhesive plaster, and the bleeding soon stops. Even wounds which are comparatively deep will usually stop bleeding, if they are tightly bound and held quiet for a time.

Fig. 28. — Showing the Main Artery in the Leg.

In front of the leg above the knee, but behind it below the knee.

Bleeding from Arteries. — An artery wound is more

serious, and must be treated promptly in order to save the person's life. If a cut or wound of any sort is followed by a forcible spurting of blood, it is certain that an artery has been cut. The only way to stop the bleeding is to compress the artery *above the cut*, that is, between the cut and the heart. Severed arteries are most common in the arms and the legs, and the treatment in such cases is simple. Figures 27 and 28 show the course of the chief arteries in the arm and the leg. Figure 29 shows a simple method of grasping the arm so as to compress the artery and stop the bleeding, temporarily, anywhere in the arm below the elbow.

FIG. 29. — SHOWING HOW TO COMPRESS THE ARM TO STOP BLEEDING.

The easiest and most effectual method of stopping the flow is, however, to put a bandage or *ligature* around the arm above the cut, and to place a stick inside it, as indicated in Figure 30. The stick is then to be turned, twisting the bandage, and binding the arm more and more tightly, until the bleeding stops. If a stone or a tightly rolled handkerchief is placed under the ligature and over the artery, less pressure is required. A physician must then be summoned as soon as possible. The ligature must be kept in position until the physician can tie the artery and prevent further bleeding. With a wound in the leg the

method of stopping the flow of blood is similar. Prompt action is of supreme importance in all such cases.

Why the Bleeding stops. — If there is a break in the water pipe laid along a city street, the water continues to flow out until the workmen have repaired the pipe. The leaking would never stop of itself. How is it then that bleeding from a vein stops itself, or can be stopped, so readily? If, whenever there was a break in the pipes, the water should freeze a short distance above the break, the ice would close up the opening and stop the leak. Something of this sort really occurs in the case of a wound. The blood does not freeze, of course, but it becomes somewhat solid; a change takes place in it which we call **clotting**.

Fig. 30. — Showing the Method of applying a Ligature.

Blood Clotting. — Blood, as we know, is a liquid. If blood be drawn into a small dish, it will at first be liquid, like water. But if it is allowed to stand for a few minutes, it stiffens, becoming somewhat jellylike. The hardening continues until the blood is changed into such a firm jelly that it will not flow out, even if the dish is turned upside down. In other words, the blood has *clotted*, as is shown in Figure 31. A great

change has been produced in the nature of the blood, and after clotting it would naturally be of no further use, as it could no longer flow through the blood vessels.

If blood is taken out of the blood vessels, it always clots in a very few minutes, no matter whether it is heated or cooled, or whether it is brought in contact with the air or not. So long as it remains inside

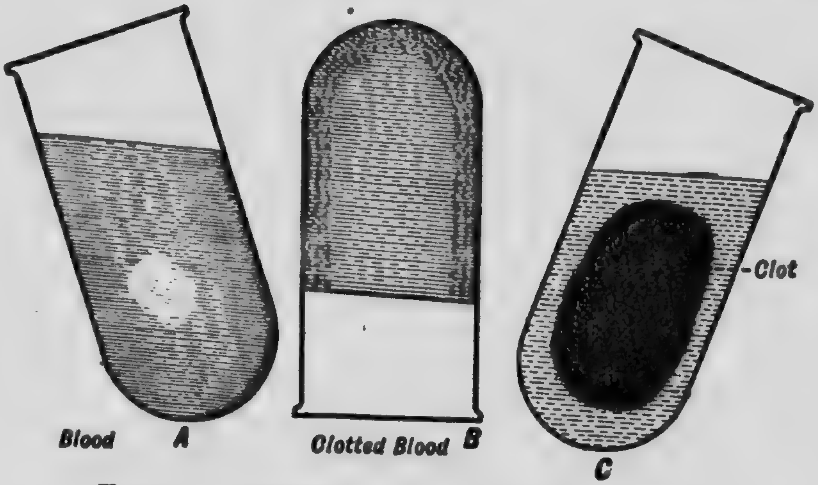


FIG. 31. — SHOWING THE CLOTTING OF BLOOD.
At *A* it is liquid ; at *B* it is solid. At *C* it is partly liquid again.

the blood vessels it continues in liquid form. If, however, the blood vessels themsel· .are injured by a cut or bruise, the blood begins to .lot rapidly near the wound.

From this fact we learn how bleeding is stopped. Whenever a bruise or a cut breaks a blood vessel, the wound at once begins to bleed. But the injury to the blood vessel causes a clotting in the blood near the bruise, and the clot soon closes the wound. As a result,

any ordinary wound soon ceases to bleed; but if there is a large cut through a vein or an artery, the blood may flow out so rapidly that it does not have time to clot. In such cases the bleeding must be stopped by a ligature or some other artificial means.

Effect of Gravity. — If we hold the hand downward for a few minutes, it becomes red, because it is filled with blood. If, on the contrary, the hand is held above the head, it turns whiter. This shows us that the blood flows down more easily than it flows up. Of course, the blood in flowing through the blood vessels, is pushed on by the force of the heart. Even when the blood flows downwards into the legs, it must be pushed by the beating heart. But the weight of the blood itself has some influence upon its flow, helping the heart to send the blood down, and holding back, more or less, the upward flow. The aiding and checking of the flow by the weight of the blood, or gravity, is, however, of no practical importance except under certain conditions, such as fainting.

Fainting. — Fainting is commonly due to lack of sufficient blood in the brain. This causes *unconsciousness.* Recovery from the fainting fit occurs as soon as the necessary amount of blood is restored to the brain. When a person faints it usually means that the heart is not beating vigorously enough to force the blood upward to the brain. We should, accordingly, assist the heart by placing the head of the patient a little lower than the body. This will help the blood to run into the head from its own weight. The return of blood

to the brain may also be hastened by stimulating the action of the heart. Dashing a little cold water upon the face hastens the beating of the heart, helps to restore the blood to the brain, and so insures recovery from the fainting fit. Our natural impulse, when a person faints, is to lift his head, but as a rule this will hinder recovery.

HOW THE FLOW OF BLOOD IS CONTROLLED

Regulation of the Heart Beat. — The circulation of the blood is produced by the beating of the heart, and at the same time the heart is partly controlled by the brain. The heart can be entirely removed from the body of a cat or a dog and yet it will continue to beat, sometimes for hours. This shows that the heart is able to beat independently of the brain. Nevertheless the brain has the power of hastening and checking the heart's action. The brain is, in fact, the central organ of the body, and as such it controls the action of every part.

Passing from the brain to the heart are two nerves which serve, like telegraph wires, to connect the two. Over these nerves the brain is constantly sending messages to the heart. Sometimes the heart beats more rapidly than is necessary, and the brain sends a message which checks its action a little and makes it beat more slowly. At other times the heart does not beat fast enough, and needs to be hastened. If, for example, a boy starts to run, he needs to have an extra amount of blood sent to the muscles. Immediately the brain sends a message that sets the heart to beating faster,

which, of course, causes the blood to flow more rapidly. After the boy stops running, at the brain's command the heart beat becomes gradually slower until it reaches the ordinary rate. There are many other occasions when a quickened heart beat is desirable.

The brain seems in every case to recognize the need, and controls the heart accordingly. All this is done without any thought on our part. We cannot by will power change the rate of the heart's beating, and usually we do not even know when a change occurs.

We can readily test the difference in the rate of the beating by counting the number of beats a minute, (1) after we have been sitting quietly for some time, (2) after we have walked up a flight of stairs or have run for some distance, and again (3) after fifteen minutes of quiet.

Regulation of the Blood Vessels. — The flôw of water from the city water pipes is regulated in two ways. The pump may work more or less rapidly as occasion demands; the faster its movement, the greater the amount of water flowing into the pipes. This action corresponds to the changes in the rate of the heart beat. The flow of water in the various houses depends upon how wide we open the faucet, whether to its full extent, halfway, or not at all. So in our bodies there is a means of changing the size of each little blood vessel, to allow either more or less of the blood to pass through.

All of the small arteries have muscle fibres running around them, as indicated in Figure 32. When these muscle fibres contract, they narrow the blood vessel,

lessening the amount of blood allowed to pass. When they relax again, the blood vessel opens and the blood flows in a larger stream. These muscle fibres are all connected with the brain, or the spinal cord, by nerves through which they can be made to relax or contract. In this way the flow of blood in any organ of the body can be increased or decreased.

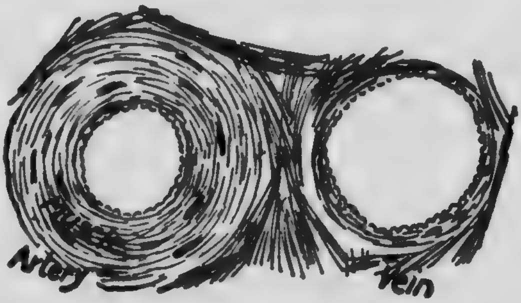


FIG. 32. — SECTION OF AN ARTERY AND A VEIN.

Showing the thick elastic wall of the artery and the thinner wall of the vein.

If for any reason a particular part of the body needs more blood than usual, it is not always necessary to increase the rate of the heart beat. The little muscles around the arteries simply relax, so that these blood vessels become larger, and at once more blood flows through them. On the other hand, if less blood is needed in a certain organ, the brain causes the muscle fibres to contract, so as to close, or partly close, the blood vessels.

When any part of the body is actively at work, it needs plenty of blood, since the blood brings it nourishment. The more vigorous the work, the greater is the amount of blood needed. The brain needs an extra supply when we think hard, the leg muscles when we run.

After a hearty dinner the stomach and the intestines need a large amount of blood for the work of digestion.

By means of the nerves from the brain (**vaso-motor nerves**, they are called), the small arteries in the intestines are made to relax and allow the blood to flow through more quickly than usual. The walls of the intestines and the stomach become filled with blood, and digestion goes on rapidly.

This large flow through the intestines necessarily draws some blood from the brain and other parts of the body. Accordingly, after a heavy meal most people are a little stupid and rather inclined to sleep. On the other hand, when a person is studying very hard, so that the brain is especially active, the blood vessels in the brain itself are relaxed to allow of a large flow of blood. It is therefore difficult to do profitable studying and to digest a heavy meal at the same time. Either the brain will take too much blood to allow of good digestion, or else the stomach and the intestines will have so large a share of the blood that the brain is sluggish and the lessons suffer.

Blushing results from a similar action of the blood vessels in the skin of the face; these vessels are relaxed, and allow an extra amount of blood to flow through them. The cheeks become thereby red and warm. On the other hand, an unusual contraction of the vessels in the face causes the skin to become pale. A *flushed* skin thus means expanded blood vessels, while a *pale* or *white* skin means contracted ones.

The Feeling of Warmth and Cold. — The expansion and contraction of the small arteries in the skin cause our feelings of heat and cold. The blood is warmer in

the interior of the body than at the surface, but since only the skin feels warm or cold, we do not notice the warmth of the blood as long as it is below the skin. When we exercise vigorously, as in running, we feel very warm. The reason is that the exercise causes the blood vessels in the skin to expand so that an extra large amount of blood flows through them. The skin becomes red and the blood so warms it that we feel the heat.

Although we feel especially warm when the blood flows rapidly through the skin, the body is in fact no warmer than usual. Indeed, the sending of the warm blood through the skin is the means by which the body cools its blood, to keep us from really becoming warmer. If the body seems likely to become too warm, it sends blood to the skin at once, to be cooled by the air. But if the body has too little heat, the blood vessels contract, and the warm blood is kept away from the surface, causing pallor of the skin. The skin blood vessels thus serve much the same purpose as little windows, which are opened or closed to regulate the temperature.

Sometimes we are deceived by the feeling of warmth. Whenever the blood vessels in the skin are opened wider than usual, so that warm blood flows through them, we may be sure we are cooling off, no matter how warm we feel. Now there are certain substances which, if taken into the stomach, cause the blood vessels to enlarge. For example, a certain amount of alcohol causes the skin to become flushed and the body to feel warm. Many people believe, therefore, that the alcohol has

actually warmed them, and so they take it on a cold day to keep them warm. Exactly the opposite is the case. The alcohol has caused the blood vessels to expand, or, in other words, it has opened the windows in the skin, and the body has begun to cool. The person feels warm simply because the skin is heated, but he is really losing heat more rapidly than before. Arctic explorers find that they cannot endure the extreme cold so well if they use alcoholic drinks.

We should never use any form of alcohol from a belief that it warms the body and helps us to endure the cold. Sometimes, after a person has been overcome with cold, and is half frozen and perhaps unconscious from the exposure, alcohol may be given as a stimulant to quicken the action of the heart and hasten recovery. Under such circumstances it is not used to warm the person, but for its stimulating effect.

SUMMARY OF THE CIRCULATION PROCESS

Let us trace briefly once more the journey made by the blood, beginning when it enters the heart after a journey around the body. It enters the right auricle and ventricle of the heart through large veins coming from the head and body. Then it is forced into the pulmonary artery, which carries it to the lungs to be purified. From the lungs it returns to the heart, this time entering the left auricle and ventricle, from which it passes into the main artery of the body. The main artery divides into branches which take blood to the head, the limbs, and the various organs; and the

branches subdivide into smaller and smaller branches which finally end in the little tubes called capillaries. There the pure blood gives up its food, and at the same time takes up the waste products.

From the capillaries the impure blood enters small veins which connect with larger veins, and these with still larger ones, until finally all unite in the two large veins which carry the blood to the heart once more.

The beating of the heart is continuous, but the rate can be increased or diminished through the action of the brain; and the blood supply of any organ can be increased or diminished by the expansion or contraction of the small blood vessels. The whole circulation is controlled without our being conscious of the fact or being able voluntarily to change it in any way.

QUESTIONS

1. What is the purpose of circulation?
2. Describe the red blood corpuscles.
3. What is the use of the white blood corpuscles?
4. What is the duty of the heart?
5. What are arteries? Veins?
6. Do any of the arteries carry impure blood?
7. How can we tell when an artery is cut? What should be done in such case? Why is such a cut more serious than a cut vein?
8. How does nature stop bleeding from wounds?
9. If the blood would not clot, what would happen when a person is cut?
10. What is the pulse? Why does a physician count a patient's pulse?

11. What are the capillaries?

12. What is fainting? What is the remedy for it?

13. How is the flow of blood regulated?

14. How is the amount of blood that each organ receives regulated?

15. Why should we not study immediately after a hearty dinner?

16. If a person should run rapidly immediately after dinner, would it help or hinder digestion? Why?

17. Why do we feel warm after running?

18. Why is it that alcohol makes a cold man feel warmer? Is he actually warmer?

CHAPTER V

RESPIRATION

ONLY as the fuel in a locomotive is burned does it drive the engine. The burning of the fuel is really a union of the coal with a certain part of the air called *oxygen*. The process is **oxidation**, and it produces heat. As a result of the burning, a large amount of another gas, *carbon dioxide*, is produced, which passes out of the smoke-stack with the smoke, and there is left in the grate a quantity of ashes. In order that the fires in the engine may be kept burning brightly, it is necessary that there be a supply of air. This is furnished by means of the draft. It is necessary also that the gases have some means of passing off, as they do through the smoke-stack. The ashes must also be frequently removed from the grate to keep the fires free, and allow the air to reach the burning coal.

The processes which take place in our bodies are somewhat similar to those in the engine. The food is *oxidized*, although the process differs much from the burning of coal, and a certain amount of heat is produced which warms the body. Oxygen gas from the air is as necessary for the body oxidation as for burning the coal. What is more, there is produced in the body the same kind of gas as in the engine, carbon

dioxide, and a certain material is left that corresponds in a way to the ashes, and of this the body must dispose. How the body gets its oxygen, and gets rid of its carbon dioxide, is a story in itself. This exchange of gases between the air and the blood is brought about by breathing, or **respiration**.

THE AIR PASSAGES AND THE LUNGS

When we breathe properly, air is taken in at the nostrils, and after passing through the large nasal cavities above the mouth enters the throat. The nostrils, as we saw in Figure 12, lead directly to the throat, so that the air has a free passage. We have seen, too, that the mouth also leads directly to the throat. If the mouth is open, air may be taken through it even more easily than through the nostrils. In either case the air passes directly into the throat, and then down to the lungs.

Mouth-breathing is not, however, the natural method of taking in air, and is always injurious if continued for any length of time. The air passes much more rapidly through the mouth than through the nostrils, and consequently it is not so thoroughly warmed when it reaches the lungs. What is more, the dust in the air is not so completely removed as when it passes through the nostrils. The narrow, irregular passages of the nose, with their moist surfaces and hairs, hold the dust and prevent it from passing into the lungs. We should carefully avoid getting into the habit of breathing through the mouth, even when walking fast or when running, lest we cause throat and lung troubles that

may be a serious menace to health. If a person should find that he really is unable to breathe excepting with the mouth open, it indicates that something is wrong in his throat or nose, and he should be examined by a physician.

The Windpipe or Trachea.—The air passes from the throat into the **windpipe** (see Fig. 12). This is a large tube at the front of the neck. As we have seen, it is always open, except that at the instant when food is being swallowed the epiglottis closes down over it like a lid. The epiglottis springs up again, however, as soon as the food has slipped by, to allow the free passage of air to and from the tube. The windpipe itself is held open by a series of hard, cartilage rings in its walls, which prevent it from collapsing.

Just within the upper end of the windpipe is situated a very important organ, the **larynx**. If we place our fingers upon the outside of the throat just below the jaw, we can feel a hard bunch move up and down as we swallow. This bunch, sometimes called the Adam's apple, is the larynx. Figure 33 shows its location at the beginning of the windpipe. Inside of the larynx are the so-called **vocal cords**, by means of which we are able to make sound when talking. Below the larynx the windpipe passes down through the neck in a straight line and enters the chest, where, as shown in Figure 33, it divides into two branches.

The Lungs.—When the windpipe divides, one branch enters one of the **lungs**, and the other branch enters the other lung. The lungs look like two elastic bags, as

indicated in Figure 33, and are capable of being distended when air is drawn in, and of collapsing when the air is expelled. Each of the bags seems to be filled with a mass of spongy material, which is made up prin-

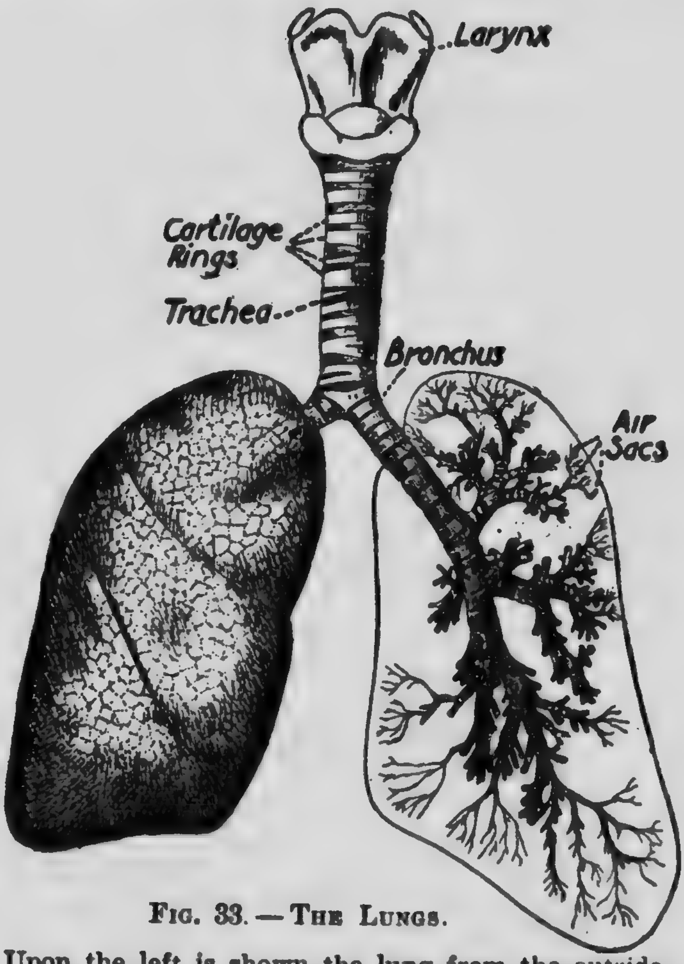


FIG. 33.—THE LUNGS.

Upon the left is shown the lung from the outside; upon the right the lung is opened to show the branches of the air tubes.

cipally of air tubes, air cells, and blood vessels. Each branch of the windpipe, on entering the lung, divides into numerous smaller branches. Each of these divides

again, and so the division continues, until finally the smallest of the branches form a system of very minute tubes similar in its irregular divisions to the twigs of a tree. The whole lung, in fact, appears somewhat like a tree upside down. Each twig ends in a small rounded sac or **air chamber**. The air taken in through the nostrils finally enters and expands these little chambers, which are shown in Figures 33 and 34. The lungs contain many thousands of the sacs, and every time we breathe they expand with the air which they take in. Thus the whole lung, being filled with air, is light and spongy. It is an excellent plan to draw several long breaths every little while, to distend the air sacs as much as possible, thus "clearing the lungs" as we say.

FIG. 34. — AIR SACS. Found at the ends of the air tubes in the lungs.

Blood Vessels of the Lungs. — We have already learned that the right side of the heart receives the impure blood and sends it through the pulmonary artery to the lungs. When this artery enters the lungs it divides and subdivides into small blood vessels, which in turn divide into very small capillaries. The capillaries are wrapped around the air sacs, appearing like a sort of net about them (Fig. 35). While the blood from the heart is flowing through the capillaries it is very close to the air which fills the sacs. It is so close, in fact, that it takes some of the oxygen out of the sacs,

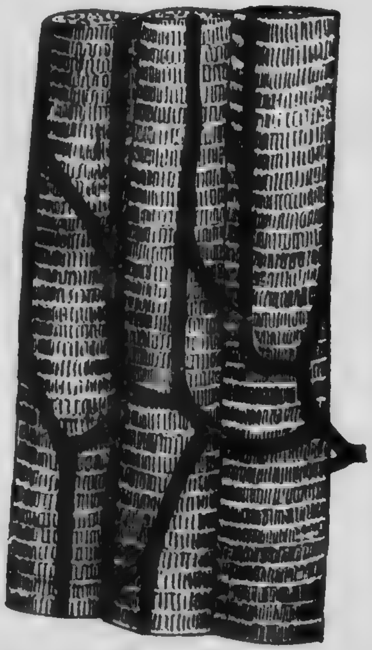


FIG. 36.—MUSCLE FIBRES.

FIG. 35. — THE AIR SAC OF THE LUNGS.

giving up to them in exchange the impure gases which it holds. After leaving these gases and taking the oxygen, the blood is purified and ready to go back to the heart.

HOW AIR IS DRAWN INTO THE LUNGS

When the handles of a pair of bellows are extended the cavity inside is enlarged, and air is sucked in to fill the increased space. If a rubber ball with a hole in it is compressed until it collapses, and is then held in a dish of water and allowed to take its normal shape, the hollow fills with water. Breathing is based upon a similar principle. The air is drawn into the lungs in much the same way that bellows are filled with air and the ball is filled with water.

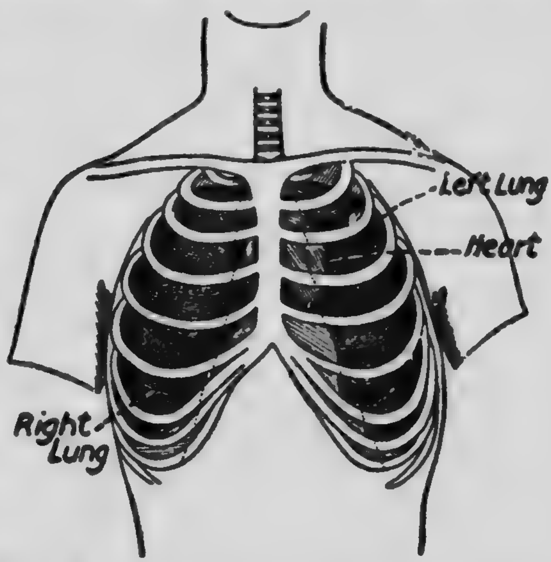


FIG. 37. — SHOWING THE CHEST WITH THE LUNGS AND HEART IN POSITION BEHIND THE RIBS.

The Chest or Thorax. — The lungs are inclosed in a box called the **chest**. This is closed in front, at the sides, and at the top by the ribs, muscles, and skin. Figure 37 shows the chest and the position of the lungs. At the rear the chest is closed by the backbone and

the ribs. A thin muscular partition, the **diaphragm**, stretches across the bottom, shutting the box up completely. The windpipe is the only opening in the chest for the entrance of air.

The position which the diaphragm would take if left to itself is that of a slight upward curve, as shown in Figure 38. Each time we draw in a breath, the muscles of the diaphragm shorten and draw it down to the position shown by the dotted line in Figure 38. This enlarges the space in the chest, and the outside air, rushing in through the nostrils and the windpipe, enters the lungs, and fills the enlarged space.

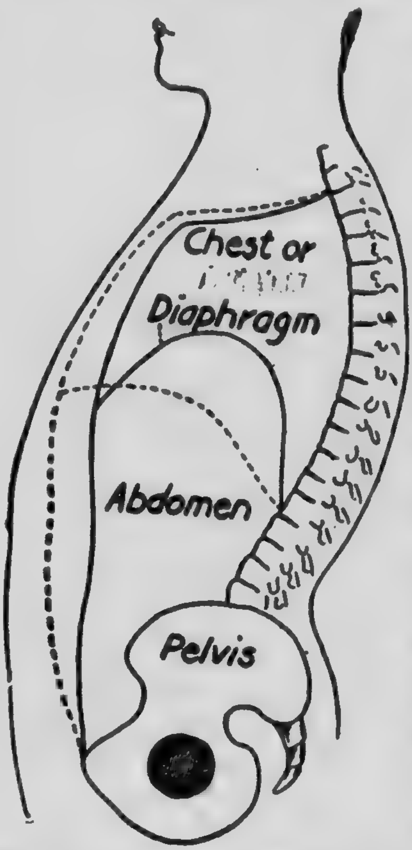


Fig. 38. — Showing the Movement of the Diaphragm in Breathing.

The dotted line represents the position at the end of an inhalation.

The diaphragm is helped by the ribs in making the space within the chest larger. The ribs, in their usual position, tend to bend downward. As we breathe, the numerous muscles surrounding the ribs raise them upward and forward, increasing considerably the space within. The dotted lines in Figure 39 show the position of the ribs when the lungs are full. Air is drawn in when we breathe simply

because of the enlargement of the cavity of the chest which sucks air in through the nostrils, much as it is sucked into a pair of bellows.

After the lungs are thus filled with air, the muscles relax, and the ribs fall of their own weight into the position shown in the solid lines of Figure 38. At the same time the diaphragm relaxes, and is pushed up to its former position, partly by its own elasticity and partly by the organs below, which it had previously compressed. Both motions decrease the size of the chest cavity, and the air is squeezed out exactly as the air is forced from the bellows by the pressure on the handles. Drawing the air into the lungs is called **inspiration** or **inhalation**. Forcing the air out by contraction is called **expiration** or **exhalation**. The whole process is controlled through nerves by the brain.

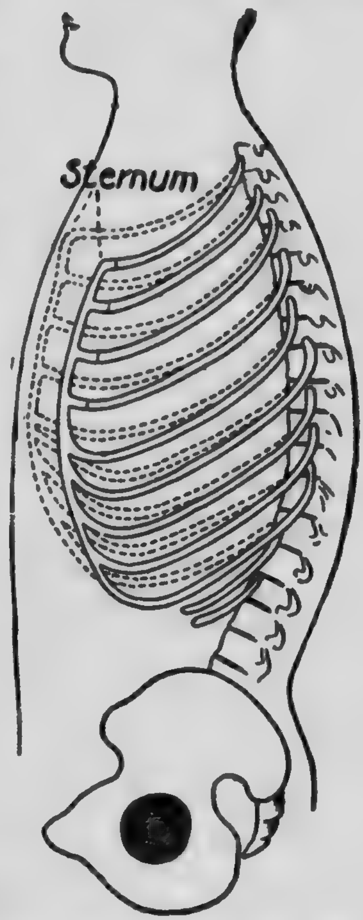


FIG. 39. — SHOWING THE MOVEMENT OF THE RIBS IN BREATHING.

Capacity of the Lungs. — A certain amount of air is drawn into the lungs with each breath, and about the same amount forced out. But the lungs are never completely filled by an ordinary

breath, nor are they ever completely emptied after the exhalation. After taking an ordinary breath we can still breathe in more air by an additional deep breath, and after an ordinary exhalation we can expel more air by an effort. Thus in ordinary breathing we change only a part of the air in the lungs. In fact, the lungs of a grown person commonly hold about 350 cubic inches of air, of which only about 30 inches are changed with each ordinary quiet breath. We might renew most of the air by very rapid and very deep breathing, but to do so continuously would be too great an effort.

Lung Exercise. — The lungs should by all means be completely filled with pure air occasionally. If the air in the little air sacs is seldom changed, but remains more or less stagnant, the sacs furnish excellent lodging places for dangerous bacteria, and they may even be the starting point for consumption, pneumonia, or some other lung disease. If people exercised the air sacs more vigorously, filling them constantly with fresh air, the danger of lung trouble would be decreased.

How shall we give our lungs the needed exercise? By drawing long, deep breaths, filling the lungs as full as possible, and then blowing out the air slowly and forcibly. If we acquire a habit of frequently filling the lungs deeply with fresh out-of-door air, we shall strengthen them, increase their capacity, and improve our general health. Persons whose work is such as to produce vigorous activity of the lungs do not need such special exercise. If one is obliged to walk up a steep hill daily, so that he becomes somewhat breathless, the lungs

receive all the exercise needed to keep them properly active. The active boy or girl ordinarily gets plenty of lung exercise in play. It is important to remember, however, that with the quiet life which many persons live, especially in our cities, the lungs need special exercise to make them strong and to give them the amount of fresh air necessary for health.

WHAT BREATHING DOES FOR THE BLOOD

How Blood is changed in the Lungs. — The blood which enters the lungs to be purified is very different from the blood which returns from the lungs to the heart. Four important changes occur in the lungs.

1. *The blood takes up oxygen from the air.* — The red corpuscles have the power of taking up oxygen from the air. Each one of the millions of these corpuscles takes from the air in the lungs as much of the oxygen as it can hold. As soon as the oxygen has been absorbed, the corpuscle becomes a brighter red than before, and consequently the blood itself is of a more brilliant color. The blood that flows into the lungs is bluish red; the blood that comes out is bright scarlet.

2. *The blood gives up carbon dioxide gas.* — The carbon dioxide gas leaves the blood, enters the air in the lungs, and is then expelled in the exhalation.

3. *The blood is cooled.* — The blood is somewhat cooled while it is flowing through the lungs. The air which we breathe into our lungs is usually cooler than the body. In an ordinary schoolroom it is about 70°. But the same air when expelled from the lungs is nearly

as warm as the body (about 98½). It has been warmed in the lungs by the blood, the blood itself being cooled at the same time.

4. *The blood loses some of its water in the lungs.* — If we breathe upon a cold windowpane, little drops of water collect, making the glass cloudy. These drops condense from the moisture we exhale. The air breathed from the lungs is usually nearly saturated with vapor. When we walk out of doors on a cold winter's morning, we can "see our breath"; that is, the water in the breath condenses into a slight fog as it comes from the mouth or nostrils. This water all comes from the blood. Thus the blood on leaving the lungs contains less water than when it enters.

How the Oxygen is Used. — After the blood has taken the oxygen from the air in the lungs, it goes directly to the left side of the heart. From there, as we have already learned, it is sent to all parts of the body through the arteries, finally reaching the capillaries. The blood flows through the capillaries very slowly, and here each red corpuscle lets go of the oxygen it took while in the lungs. The oxygen passes at once from the blood to the tissues of the body around the capillaries. The red corpuscles are thus the *oxygen carriers.* They go to the lungs, seize the oxygen, and then carry it to every part of the body needing it. After they have given up the oxygen they become bluish red, so that the blood which leaves the capillaries to go back through the veins to the heart is a dark bluish red.

We have already seen that the oxygen is brought into the body to unite with the food, just as it unites with the fuel in a locomotive, and that as a result there is produced the waste gas, carbon dioxide. While the blood is passing through the capillaries, it not only gives up oxygen to the tissues but it takes from them the carbon dioxide which has been produced. Thus when it comes back from the tissues to the heart, the blood is carrying carbon dioxide in the place of the oxygen. Such blood is called *venous blood*, and is said to be impure because it contains waste products. When this blood reaches the lungs again it gives off the waste carbon dioxide it is carrying and gets another load of oxygen.

Respiration is then an *exchange of gases between the body and the air.* The blood is all the time passing through the lungs where it gives up carbon dioxide, water, and other gaseous waste products and takes oxygen. Going thence to the various parts of the body, it supplies them with the oxygen and takes away the carbon dioxide. If anything hinders breathing, there is trouble, for the same reason that a fire will not burn unless there is a draft to furnish air to the burning coal. If breathing stops for more than a few minutes death follows, since the body is then unable to obtain oxygen or get rid of waste gas.

Breathing and Exercise. — We can readily understand why, if we exercise vigorously, the rate and the depth of breathing will be increased. If an engine is to work rapidly, it must have a good draft, and it must

burn large quantities of coal; a large amount of ashes will be left, and a great deal of smoke will issue from its chimney. So with our bodies. If we are to work our muscles vigorously, we must have a large supply of oxygen to oxidize the necessary food, and an increased amount of waste will be produced. The blood must consequently flow faster than usual, both to furnish the oxygen and to carry off the waste. To accomplish this the heart begins to beat faster so as to increase the speed of the blood, and at the same time our breathing becomes more rapid, so that the rapidly flowing blood may be supplied with oxygen, and all the waste may be carried away.

VENTILATION

Need of Ventilation. — It is evident that we need a great deal of pure air. The rooms in which we live should be well ventilated. There are two purposes in ventilation: 1. To furnish us with a sufficient supply of oxygen; 2. To provide air that can carry off dust, noxious gases, and moisture.

Anything which uses up the oxygen in a room, or which allows too large an amount of breathed air to accumulate, renders the air unwholesome. If a great many people are breathing the air in a room, or if gas or oil stoves or lamps are using up the oxygen and giving out carbon dioxide, the air, unless changed, becomes oppressive and poisonous. In such cases it is especially necessary to attend well to the matter of ventilation.

Evils of Indoor Life. — People who live in warm climates spend much of their time out of doors. We in the colder climates have formed the habit of living in close rooms, where we remain for hours at a time. In the close rooms we are often forced to breathe over and over the air which has already been breathed by ourselves or other people, and this is most unwholesome. The habitual breathing of impure air is partly the cause of some of the lung diseases, as pneumonia and consumption. This does not mean that people living out of doors never have lung troubles; but such diseases are most common among those who live in close rooms. City workmen, though better fed than country workmen, are usually less healthy. If we could be in the open air most of the time, we should avoid many of these difficulties; but since in cold climates this is not pleasant in winter, we must at least keep our rooms supplied with plenty of fresh air.

The Need of Fresh Air. — Many people arrange their living rooms with a wholly mistaken idea of what is healthful. They seem actually afraid of *fresh air.* So careful are they to prevent drafts that they exclude fresh air. They think that they take cold because the rooms are not warm enough, or because of changes in temperature, so they keep the air as uniformly warm as possible. Probably more colds are due to overheated or impure air than to drafts or cold air. We take cold from drafts frequently because we accustom ourselves to living in warm rooms. A temperature of from 65° to 70°, depending upon how actively we are

employed at the time, is the proper temperature for living rooms in cold weather.

A very large class of people consider *night air* especially dangerous, and for this reason they sleep in rooms closed up tightly, to prevent fresh air from entering. Night air is no more injurious than day air, except that it is likely to bring mosquitoes, which should be kept out of the sleeping room; and there is no time when a person should be more particular that the air is pure than when he sleeps. The attempt to shut out night air from sleeping rooms is a grave mistake, and this is true both in winter and in summer. Fresh air is one of nature's best remedies for many diseases. If we determine to make it a point through life to breathe plenty of wholesome, fresh air, we have laid a firm foundation for vigorous health.

How Rooms are Ventilated. — More or less fresh air gets into the rooms of an ordinary dwelling house, no matter how tightly they may be closed. If a stove is used in a room, the fire causes a continuous draft up the chimney; this draft always removes air from the room, and fresh air is drawn in from outside to take its place. The air comes in through the cracks about the doors and windows, through the keyholes, and more or less through cracks in the floors. The direction of the currents of air may be seen from Figure 40. When there are only one or two persons in a room, and the doors are opened frequently, sufficient fresh air is usually supplied from these sources. At night such ventilation is not enough. Unless the wind blows very hard, some

arrangements should be made for constant change of air, such as opening a window at the top in such a way that those sleeping in the room will not feel a direct draft. An open fireplace, even if there be no fire in it, is an excellent means of ventilation, as shown in Figure 40.

In houses heated by means of hot-air furnaces special devices are usually adopted for supplying fresh air.

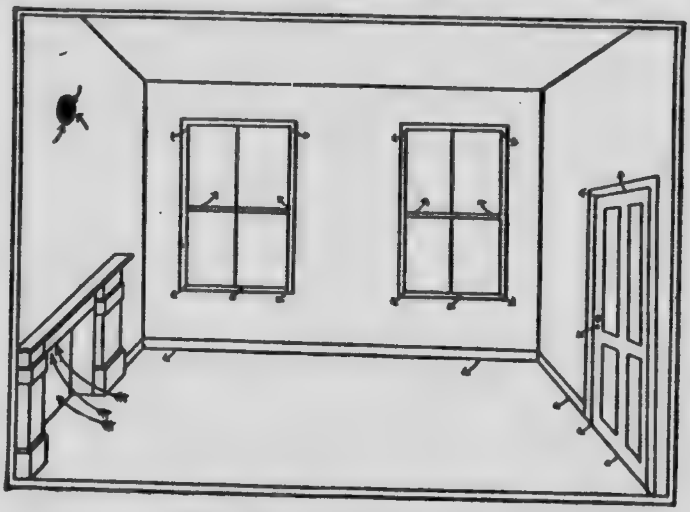


FIG. 40. — VENTILATION.
Showing the means by which air enters and leaves an ordinary room.

The furnace is connected with what is called the cold box, which is open to the outdoor air. The air enters this box, passes into the furnace, is there heated, and then rises through the flues into the different rooms. All the while air is passing out of the rooms through cracks in the doors and windows, or rising through halls or ventilating flues in chimneys, which are usually left open in such houses.

When houses are heated by steam radiators it is not so easy to keep the air pure; for although currents of

air move up and down in the room they do not readily pass out, and we must depend for fresh air upon flues and open fireplaces. The difficulty in keeping a free circulation of air is partly the reason why a room heated by steam is apt to be "stuffy." In such a room there should always be some special arrangement for the outlet and inlet of air. Sufficient movement of the air may be obtained by means of open fireplaces, flues in the chimneys, ventilators around the windows, or windows slightly open at top and bottom. When a house with many doors and windows has many of its rooms opening into each other, ventilating flues are not especially necessary.

When a room — such as a schoolroom or a public hall — holds a number of persons, special means should be adopted for replacing impure air. Such rooms are usually provided with special ventilating apparatus.

It is worth while to remember, in any case, that cold, fresh air, from whatever source it may come, is less injurious than breathing repeatedly the air of a close, ill-ventilated room. There is one simple test of the ventilation of a room: Does the air seem fresh and sweet as you come from the pure outside air?

HOW TO RESTORE RESPIRATION

Occasionally some accident stops a person's breathing and tends to produce suffocation. For example, when a person is submerged in water he can no longer take air into his lungs. If, however, the drowning person can be removed from the water

while the heart still beats, and breathing can be started again, his life can usually be saved. After being taken from the water, the patient should be placed so that the head is lower than the shoulders, and turned face downward, to allow the water to run out of the mouth and throat.

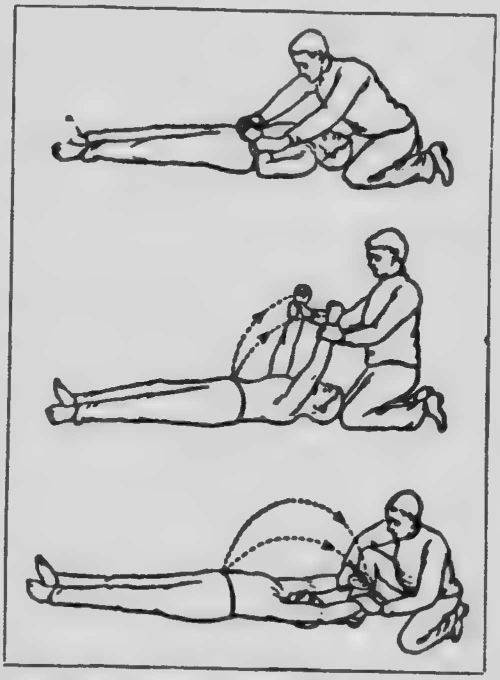


FIG. 41. — THE METHOD OF MOVING THE ARMS TO PRODUCE ARTIFICIAL BREATHING.

The process of *artificial breathing* should then be started. The patient should be placed on his back, with the head on a level with the body. The arms should be first pressed against the sides of the body, and then raised outward and upward until they meet above the patient's head. Lifting the arms in this way raises the shoulders and ribs; the size of the chest is thus increased, and air is drawn into the lungs. It is important to know that the air actually passes into the lungs. To be sure of this, the tongue must be drawn forward so as to open the throat and permit the air to pass. After the arms have been lifted, they should be lowered again, while a second person, if possible, presses the abdomen and sides of the body. The

lowering of the arms and the pressure on the abdomen tend to force the air out by compressing the chest. The raising and lowering of the arms in this manner should be continued regularly from ten to twelve times a minute, and should be kept up until *natural breathing* starts. Although this work is hard, it should be kept up for at least two hours if normal breathing is not resumed earlier.

A feather or other light object placed in front of the mouth will show when natural breathing begins. If there is any motion of the feather to indicate natural breathing, the movements of the arms may be stopped. The person should then be wrapped in warm clothing or in blankets, and nature will complete the restoration, although it will be an aid to have the extremities of the patient rubbed during the whole process. This method of restoration should be employed if a person becomes nearly suffocated from any cause. Persons have sometimes been in the water a quarter of an hour or even longer, and have still been brought back to consciousness.

QUESTIONS

1. What gas is necessary for oxidation? What products result from oxidation?
2. Why should we keep our mouths shut except when talking or eating?
3. Where is the windpipe?
4. Of what use is the larynx?
5. Where are the lungs situated?
6. How does the blood get oxygen from the lungs?
7. How is air drawn into the lungs?

8. Could a person breathe if there were a hole through the chest? Why?

9. What form the walls of the chest?

10. How is the chest cavity made larger or smaller?

11. If air is taken into the chest only, why does the abdomen swell out with each inspiration?

12. How much of the air in the lungs is changed at a single breath?

13. How can we exercise the lungs?

14. What four things happen to the blood in the lungs?

15. What does the blood do with the oxygen it takes from the lungs?

16. If one should have too few red corpuscles in his blood, what would be the result?

17. What is respiration?

18. When you are running, can you breathe more easily through your mouth? If you do, can you run farther?

19. Why does a schoolroom need better ventilation than a common dwelling room?

20. What are the purposes in ventilation?

21. What are the evils of indoor life?

22. How should rooms heated by stoves and furnaces be ventilated?

23. What may be done to ventilate houses heated by steam?

24. How may natural breathing be restored when a person has been almost drowned?

CHAPTER VI

THE FRAMEWORK AND MOTION OF THE BODY

THE stomach digests food, the heart and the blood vessels are in constant action, the lungs never cease to expand and contract as long as we live. Those organs, then, all have a part in aiding us to accomplish the work that is given us to do. But with stomach, heart, and lungs alone we could neither step, nor speak, nor move in any way. We must have in addition *muscles* and *bones*. Of these our bodies are largely made, and it is to repair and renew these, as well as to render them of practical use, that we possess the organs about which we have already studied.

THE SKELETON

Most of the parts of our bodies are soft, and if there were not a hard framework to support them, we should be nearly as flexible as jellyfish. But inside the pliable flesh we have solid **bones**, which serve, like the beams of a house, as a support for the softer parts. This framework of bones is called the **skeleton**. A grown person has in his body two hundred different bones. A child has even more, but several of the bones grow together later, making just two hundred.

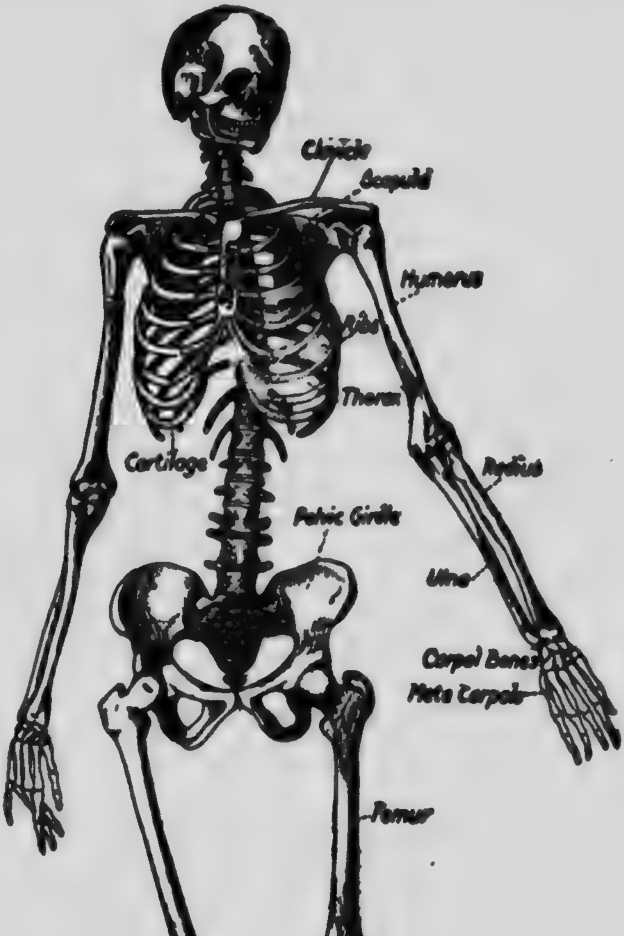


FIG. 42. — THE HUMAN SKELETON.

The bones are of different shapes and sizes. Figure 42 shows the framework of the body, indicating the position and shape of the various bones. As will be seen from the figure, there is in the middle of the back a strong support, called the **backbone**. It is not one single piece, however, but a series of small bones fitting snugly together and capable of being moved. If the back contained only one bone, it would be stiff and easily broken, but this series of small bones enables us to bend the back without danger of breaking it. Each of the smaller bones of the back is called a **vertebra**. Figure 43 shows two vertebræ. Many other animals have backbones made up of vertebræ. These include *fishes*, *reptiles*, *birds*, and the *four-footed animals* with which we are familiar. All such animals are called *vertebrates*.

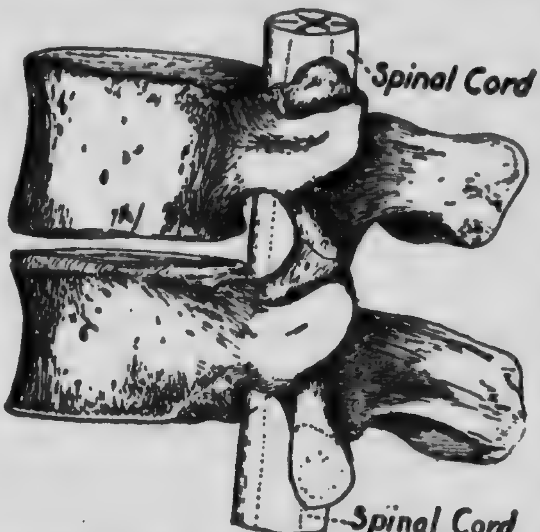


FIG. 43.—TWO VERTEBRÆ IN POSITION. Showing the spinal cord passing through them.

Figure 42 shows a large, rounded box just above the backbone. This is the **skull**, which forms the head. A side view is given in Figure 44. The skull is one of the most important parts of the body, because of the organs it contains. In it are the *brain*, the *eyes*, the *ears*, and the organs of *taste* and *smell*.

The chest, as we already know, contains the heart and the lungs. It is nearly surrounded by curved bones called the **ribs**. These extend from the backbone around to the front. The heart and the lungs

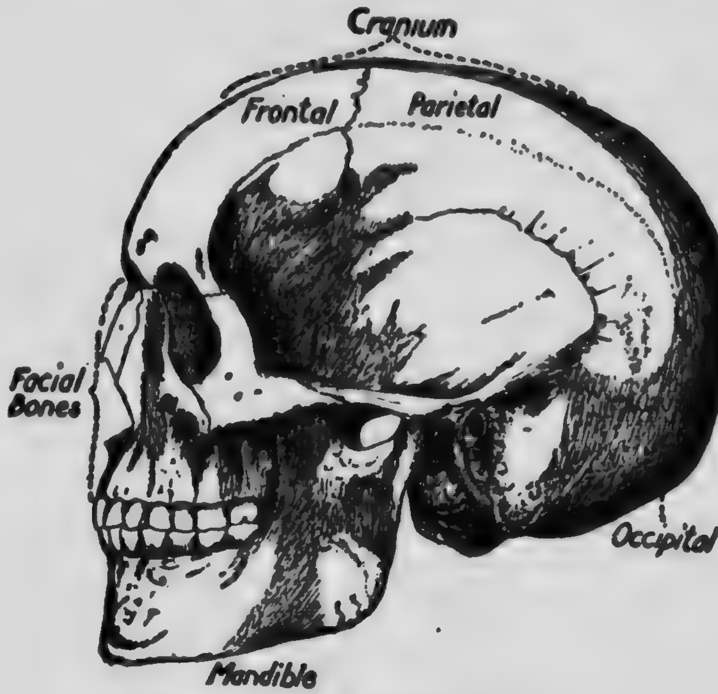


Fig. 44.—The Human Skull.

are surrounded and thoroughly protected by these ribs and the breastbone, or **sternum**.

Each of the arms and legs is made up of several bones. In Figure 42 these bones are named. The bones of the arms and legs are the longest in the body. Since they are the ones that must bear the heaviest strains, they are also the strongest bones of the body.

THE BONES

Structure of Bone. — The different bones are of various shapes, but they are all so made as to have the greatest *strength* and at the same time to be comparatively *light*. For example, the long bones of the leg and the arm, which must bear the greatest strains, are hollow. Figure 45 represents the longest bone of the leg, cut open lengthwise. At the ends the bones are spongy, but throughout the length of the shaft they are hollow. This shape gives the greatest possible amount of strength to the bone for a given weight of bony substance. Although not all the bones are hollow like those of the leg, still all are so built as to make the skeleton strong and light. This allows greater ease of motion than would be possible if the bones were heavier, and yet renders them sufficiently strong for the work they must do.

Fig. 45. — A Section of the Femur. Showing the spongy ends and hollow centre.

Bone Materials. — Bones are made of two different materials, one of which is called *mineral matter*, the other *animal matter*. The mineral matter is hard and brittle, and gives stiffness to the bone. If we put a bone upon a hot coal fire, and allow it to stay there for half

an hour, it will be very much changed. Though the shape will be the same, the heat has made the bone light and very brittle, so that it can be crumbled to a powder in the fingers. The hot fire has burned the animal matter out of the bone, leaving only the mineral matter, which is something like stone, and cannot be burned. On the other hand, if we put a small bone, such as a chicken bone, into a dish of dilute nitric acid and allow it to remain there for a day or two, the acid will take out all the mineral matter. Upon removing the bone from the acid, we shall find it unchanged in shape and size, but soft and flexible, so that we can bend it, and perhaps even tie it into a knot. What is left is animal matter only.

The mineral and the animal matter are united in bone so as to form one substance. The animal matter gives *strength*, while the mineral matter gives *hardness*.

Bones of Children. — Occasionally a child may fall down a flight of stairs with no ill effects save a few black-and-blue spots, while the same fall would be likely to injure a grown person seriously. The reason is that there is proportionately more animal matter in the bones of children than in those of adults, and the bones of children are therefore more easily bent and are not so brittle. In very early childhood the bones are made entirely of animal matter, and are consequently soft and flexible like the bone which has been soaked in acid. As the child grows, more and more of mineral matter is deposited in the bones, until finally they become hard and stiff.

During the first few years of a child's life the bones are so flexible that they can be bent out of shape more easily than in later life. For this reason special pains should be taken to teach children to hold the body erect. A good carriage in walking can be learned by every one, but most easily by children. The chest should be held up properly, and the chin kept in, not thrust forward. If the chest is kept up and the shoulders are thrown back, the body will take the best position for walking and standing. When sitting we should take care to sit with head erect, and with the back against the back of the chair or bench.

Misshapen Bones. — If the bones of a child are constantly bent in one direction, they will be deformed. Although it is easy for a child to stand and sit erect, it is equally easy to become "round-shouldered." After the bones have hardened it is as difficult to change the habits as it was easy to form them, and later in life it may be impossible. Any kind of dress that causes strong and long-continued pressure on the bones is likely to cause a misshapen body.

Wearing tight shoes will deform the bones of the feet. Figure 46 indicates the shape of the toes of a

Fig. 46. — The Cramped Foot.

Fig. 47. — The Uncramped Foot.

person who wears tight shoes. Figure 47 indicates the shape the foot takes when it is not cramped. Wrongly

shaped and tight shoes cause much discomfort and render walking difficult, besides putting the feet in such a condition that the person is likely to suffer from the effects all through life. Deformed feet may be

Fig. 48. — An Improperly Shaped Shoe.

Fig. 49. — A Properly Shaped Shoe.

produced by shoes with narrow toes or with heels so placed as to throw the weight of the body upon the toes, as shown in Figure 48. A properly shaped shoe is shown in Figure 49.

A habit even worse than pinching the feet is that of wearing tight bands round the waist, or tight corsets. This gives rise to serious deformities, affecting not only the bones but also the important vital organs of the abdomen which are pressed out of proper position. The leather belts sometimes worn by boys and young men with outing costumes, if drawn tight around the waist, instead of being placed over the hips, are almost equally bad. Good health requires that the body be allowed to grow as nature intended, unconfined by tight clothing.

Habits of stooping over one's work, of leaning against a support instead of standing erect, of standing constantly upon one foot without bearing sufficient weight upon the other, of walking or sitting with stooped shoulders and with the head thrown forward, or of wearing clothing which binds the body — any of these habits will destroy the beauty of the form and impair bodily strength. Among the prime necessities for attractiveness in appearance is an erect manner of walking and sitting, without slouching. The cadets in the military schools owe much of their fine appearance to constant drills, which exercise all the muscles, and which keep the body erect.

Repair of Broken Bones. — As many a boy knows from personal experience, bones will occasionally get broken in spite of the fact that they are tough and strong. Very fortunately, unlike broken teeth, bones when broken can be mended. Each bone is supplied with one or more tiny blood vessels, which furnish blood for its nourishment. The animal matter in the bone is *alive*, and so is able to grow.

If, after a bone is broken, the two ends are brought nicely together, this living part of the bone begins to make new bony material, which grows between the ends, finally uniting them again as strongly as ever. The bone must be kept still until it is firmly knit, for any motion would pull the ends apart. For this reason the physician binds the broken bone tightly in splints. The *setting of a broken bone* consists simply in bringing the broken ends together and binding them in the proper position.

Since there is more animal matter in the bones of a child than in those of a grown person, broken bones are more easily mended in childhood. In old age the amount of animal matter is less, so that the bones are more brittle and more easily broken. They are also less easily repaired.

CARTILAGE

The framework of the body is not wholly bone. A part of it is made of a substance called **cartilage**. This is so soft that it can be cut with a knife. It is so flexible that it can be bent easily, but at the same time it is very tough. It is found in several places in the body where there is need of greater flexibility than bone would give. For example, the ribs are united with the breastbone at the front of the chest (see Fig. 42) by little pieces of cartilage. This makes them slightly movable and not easily broken. Little cushions of cartilage are also found between the vertebræ of the backbone, as indicated in Figure 50. Here they relieve the jar which would result from a jump, if the bones actually touched each other. There are pieces of cartilage around the larynx, and the outer ear is made entirely of cartilage covered with skin. Cartilage

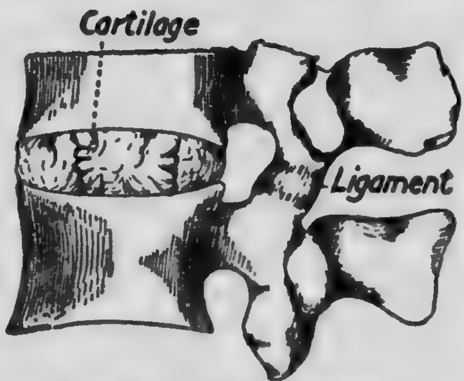


FIG. 50. — TWO VERTEBRÆ. Showing the cartilage cushion that separates them.

is not easily broken, but if once severed, it does not mend so easily as bone.

JOINTS

When we consider that the framework of our bodies is made of two hundred separate pieces, we wonder how they can ever be united in a firm structure. They are fastened as firmly as the parts of a house are nailed together. In some places, as in the skull, they are so united that they cannot be moved. In other places, as at the elbow and in the fingers, they can be turned about freely. Whenever two bones come together they form **a joint**. If it were not for our joints we could not move ; and when an accident injures a joint, we become stiff and lame. There are two principal kinds of joints in the body, the **hinge joint** and the **ball-and-socket joint**. Let us see what each is like.

A Hinge Joint. — The bones forming a hinge joint can be moved back and forth in one direction only, like a door on its hinges. The joints at the knee and the elbow are of this character, as is also each joint of the finger. If we try to move the finger or the elbow, we find that it will move in one direction only. The hinge joints are all so much alike that we need to study only one in detail. Let us take the **knee joint** as an illustration.

Two bones come together at the knee to form the joint, — the thigh bone, or **femur**, and the shin bone, or **tibia**, as shown in Figure 51. The ends of these bones

are large and rounded, and the two fit together so as to be very easily moved. As can be seen from Figure 51, these bones are so shaped that they can be moved back and forth, but not sidewise. The ends

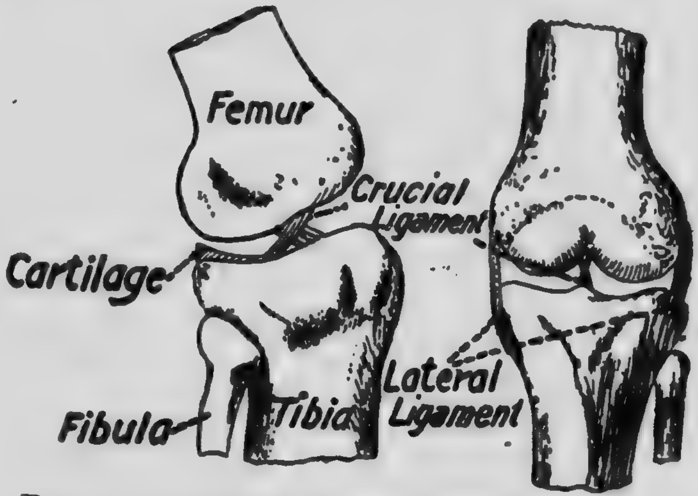


Fig. 51. — The Bones forming the Knee Joint.

of the bones, which are rounded and smooth in themselves, are made still smoother by being covered with a layer of soft cartilage.

To keep the parts of a bicycle in smooth r. ning order we oil them. The various joints of the body are provided with a liquid that takes the place of oil in the wheel. This is the way it is arranged: the bones of the joint are partly surrounded by a thin membrane or tissue, which supplies a liquid to the joint between the two bones. The liquid moistens the ends of the bones, thus preventing friction. If it were not for this liquid the bones would rub against each other, and it would be impossible to use the joint. The

shapes of the bones themselves and their smooth ends, together with the liquid, allow very free motion.

How the Bones are held together. — No matter how nicely two bones might be fitted together, if they were not well fastened in some way the slightest twist would put them "out of joint." As it is, a bone occasionally

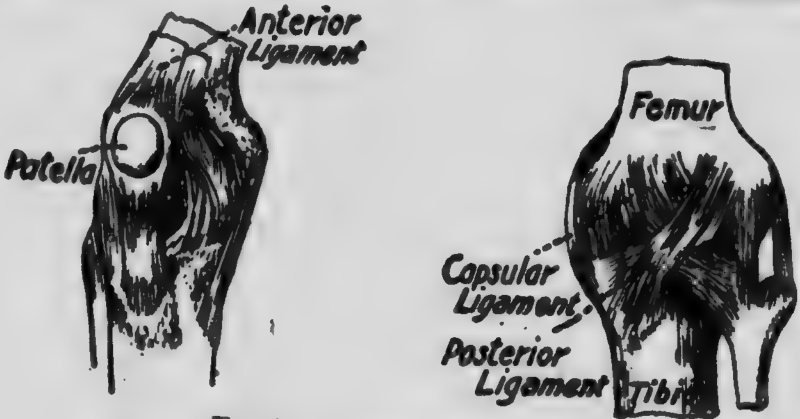


Fig. 52. — The Knee Joint.
Showing the ligaments connecting the bones.

slips out of place, but only when there is a severe strain of the joint. To avoid such danger the ends of the bones are fastened together by two kinds of connecting bands which extend from one bone to the other. These are ligaments and muscles.

The **ligaments** are made of a white, tough, flexible substance. Several ligaments may be seen in Figures 51 and 52. They pass from one bone to the other across the joint. Some of them are placed in front, some at the sides, and some at the back. The ligaments are, however, rather loose, so that while the bones cannot slip out of place, they might, if they were held in no other way, move too freely.

In addition to the ligaments, therefore, the bones are held in position by means of certain **muscles**. The motion of the bones at the knee joint is produced by the muscles, all of which lie *above* the knee. From the ends of the muscles, long, slender *cords* or *tendons* pass down over the knee joint and are attached to the bones below the knee. These muscles are elastic and, being slightly stretched, they help to hold the bones in close contact. Outside of the muscles is the *skin*, which covers the bones, tendons, ligaments, and muscles, forming a protection for them all.

We move our joints so unconsciously, as we take a step forward or sit down in a chair, that we hardly realize how complicated they really are. But when we consider that so complicated and well-fitted an arrangement is provided simply to enable us to move a knee, we cannot fail to hold these bodies of ours in great respect. A single hinge joint means that we have two smooth bones rounded just so as to fit into each other, strong ligaments to bind them together, muscles and tendons to assist in movement, and a protecting skin surrounding all.

Other Hinge Joints.—The other hinge joints of the body are like the knee joint. In all cases the bones are rounded and are moistened with the liquid to prevent friction. All are held together by muscles and ligaments, and all are so arranged that they can be moved in only one direction. The joints at the elbows, at the wrist and ankle, and in the fingers and leg are all hinge joints.

A Ball-and-Socket Joint. — To show the arrangement of a ball-and-socket joint we will study the **shoulder joint.** In general such a joint allows the bones to move in every direction. We can lift the arm above the head, to the front, to the side, turn it around, and bend it backward as far as the hinge joint at the elbow will allow. The two bones which form the shoulder joint are the shoulder blade, or **scapula,** and the upper arm bone, or **humerus.** The shapes of these bones may be seen from Figure 53.

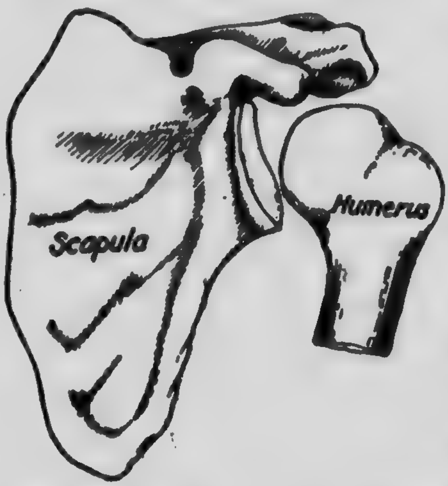


Fig. 53. — The Bones of the Shoulder Joint.

As is evident from the illustration, the shoulder blade has a somewhat rounded hollow. The upper end of the arm bone is rounded like a ball and fits into this socket or hollow. Since the end of the arm bone is a ball, and the socket in the shoulder blade is a hollow cavity, the arm can be moved in all directions. It is this shape of the bones that gives us our great freedom in lifting the arms. The ends of the bones are not only rounded, but they are made particularly smooth by being covered with cartilage, and they are also moistened with liquid like that in the hinge joint.

The bones are bound together at the shoulder by just such strong bands as we saw at the knee. There is,

however, as Figure 54 shows, only one important ligament. It is a loose, leathery sac fastened to the shoulder blade. From the shoulder blade it passes over the joint on all sides, and is attached to the upper end of the arm bone, so as to cover the joint completely, and hold the end of the arm bone in the socket. If this ligament should be cut, the bones could be taken apart very easily.

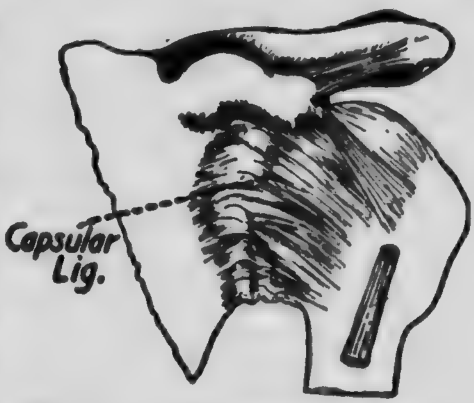


FIG. 54. — THE SHOULDER JOINT.
Showing ligaments.

The strength of the shoulder joint is due very largely to the fact that it is surrounded by strong muscles. These muscles cover the joint on all sides, giving it great strength and firmness. The muscles in the shoulder have tendons which pass down over the joint and are fastened to the arm bone, thus holding it firmly in position.

Other Ball-and-Socket Joints. — The only large ball-and-socket joints in the body, besides those at the shoulders, are at the hips. The hip joint allows the leg to be moved in various directions, but the movement is not quite so free as that at the shoulder.

Injuries to Joints. — There are two kinds of injuries to joints which are common. They are **dislocations** and **sprains.**

A bone pulled out of its place in the socket pro-

duces a **dislocation.** If, for example, a fall or a wrench should pull the end of the arm bone from the hollow in the shoulder blade into which it fits, we say the shoulder is dislocated. When a bone is thus wrenched from its proper position it cannot be moved in the ordinary way. The bone must be put back in its normal place in the joint. This should be done by a physician, unless it chances to be one of the small bones in the finger, which almost any one can pull back into place by slightly pulling the bones apart and then slipping the dislocated bone into position. When a bone is dislocated, it is very likely that some of the connecting bands or ligaments may be strained or slightly torn.

A **sprain** is a tear or strain in one or more of the ligaments of a joint. A sprain is common in connection with dislocated joints, but it occurs frequently, also, when there is no dislocation. A violent strain at any joint may cause such a pulling on the ligaments as to injure them and produce a sprain. The injury is sometimes very slight and sometimes very great. A sprain may be even more serious than a dislocation or a broken bone, requiring a longer time to heal. In case of a sprain, the joint should be placed in a comfortable position. Water, as hot as can be endured, should then be applied, and this should be followed by cold water. The joint should be bound tightly with bandages. It is wise, of course, to rest the joint, but it is not wise to keep it perfectly still during the healing process, lest it be stiff for a long time. The sprain will be more quickly healed if, beginning say a day or

two after the accident, the joint is used a little each day.

THE MUSCLES

A large part of the food we eat is used to enable us to move. The motions of the body are brought about by the **muscles**. The lean part of meat consists of muscles, and the muscles in our bodies are very similar in appearance to lean beef, as it comes from the market. The joints, ligaments, and tendons of themselves would be unable to move the body. It is through the muscles that the power is applied.

Structure of a Muscle. — To understand the structure of a muscle, let us look at the one in the front part of the upper arm, known as the **biceps**, which we see represented in Figure 55. The biceps muscle, as the figure shows, is a rather long mass of flesh, large in the middle but tapering at the two ends. The middle part is made up of reddish flesh, and is the muscle itself. At the ends firm, white bands or cords, which neither contract nor expand, connect the muscle with the bones. These are **tendons** or **cords**.

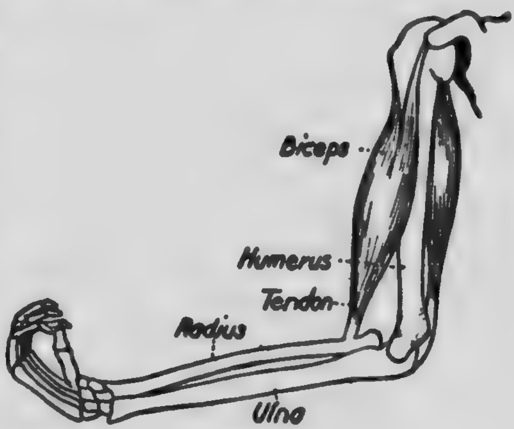


Fig. 55.
Showing the method of attachment of the biceps muscle to move the forearm.

All the muscles in the body are connected with bones by such tendons. The tendons differ in length, some of them being very short. A series of such cords at the wrist extends from the arm to the fingers, and at the ankle from the leg to the toes.

Fig. 56.
Showing the muscles and tendons of the arm.

If we grasp the left arm just below the elbow with the right hand, and then open and close the fingers of the left hand, we can feel the motion of the arm muscles. These muscles move the fingers, and are connected with them by the long tendons which pass to the finger bones. If we clinch the fingers of the left hand and grasp the wrist with the right hand, we can feel how tightly the tendons are stretched as they pass along the front of the wrist. Figure 56 shows their arrangement.

A muscle seems to be a solid mass of flesh. If we examine it under a microscope, however, we find that it is really made up of an immense number of threads or **muscle fibres**, as they are called. We can see how the fibres are arranged, from Figures 57 and 58. These muscle fibres are too small to be seen without a microscope. They run lengthwise in the muscle, and they are very numerous. They are bound together by a thin, delicate substance which fastens them firmly to one another.

Great numbers of minute blood vessels run in and out among the fibres, furnishing the muscle with nourishment, as shown in Figure 36, facing page 108. These blood vessels are the capillaries which, as we learned, receive the blood when it leaves the arteries, before its return to the heart by way of the veins. The walls of the capillaries are so thin that the food which is

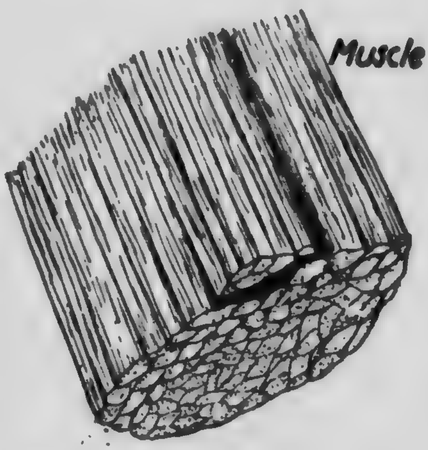


FIG. 57. — A BIT OF MUSCLE. Slightly magnified.

FIG. 58. — A BIT OF MUSCLE. Highly magnified, showing muscle fibres.

in the blood passes through them to the muscle fibres, giving them power to move and building them up.

Involuntary Muscles. — There is another kind of muscle which we hear less about. These muscles are called *involuntary* muscles, because we do not consciously control them. The most important are those which form the walls of the stomach and intestines and propel the food, and those which contract and expand the arteries.

and thus regulate the flow of blood. These muscles are very different in appearance from the ones we have just described, but they also are made of microscopic fibres, bound together in flat masses. They are much more sluggish in their action than the other muscles, and we not only have no control over them, but we are not even conscious of their action. But since they drive the food along the intestines and control the flow of blood, they are of great importance.

The Contraction of a Muscle. — If we stretch a rubber band, it becomes longer and thinner; when we let go of the ends, it shortens and becomes as thick as before. In somewhat the same way the muscles of the body are shortened, the muscle growing thicker as it contracts. If we clinch the left fist, grasp the left arm above the elbow with the right hand, and then lift the forearm forcibly, we find that the biceps muscle becomes larger and harder as the hand is raised. After the arm has been lifted, the muscle may hold it up for a time, but to do so constant effort is required. The moment we relax the effort the arm falls of its own weight. To lift the arm the muscle must be contracted, but no muscular effort is required to lower it.

There is, however, on the back of the arm, as shown in Figure 55, a muscle which acts in the opposite way from the biceps. If this muscle shortens or contracts, it pulls the arm down, stretching the biceps, as may be understood from Figure 55. The two muscles thus form a pair opposed to each other; when one of them contracts, the other is lengthened. One lifts the arm

up, and the other straightens it. It is the contraction of a muscle that produces motion or action.

What makes the Muscles contract. — In addition to the blood vessels in each muscle, there is connected with it a white cord — a **nerve**. This nerve is larger in the large muscles than in the small ones. The nerve is made up of *nerve fibres,* and each muscle fibre receives its nerve fibre. All of these fibres are connected with the spinal cord, and through the spinal cord, with the brain.

Why are the muscles connected with the brain? Just this: The nerves serve much the same purpose as electric wires. The muscles never contract of their own accord any more than an electric bell will ring itself. To ring the bell we must press a button. This sends an electric current through the wire and causes the bell to ring. In about the same way the muscles of the body act, when the proper kind of message comes to them. If the current, or **stimulus**, as it is called, never comes, the muscle will remain quiet forever. The stimulus is given to the muscle through the nerves. The brain, which is the central station for all kinds of action, is able to send stimuli down to the muscles through these thousands of little threads, and when the muscles get the message they contract. The involuntary muscles are excited into action in the same way, for, although we do not will to move them, the brain sends stimuli to them as it does to the other (voluntary) muscles.

This power which the brain has over the muscles

is very wonderful. Not only can the brain cause a single muscle to contract at any time, but it can cause many muscles to act together, either in connection with one another or separately. For example, when a boy throws a stone, he lifts his arm, closes his fingers about the stone, presses one foot hard against the ground, and sets his body firmly to assist in the throwing; then he must quickly contract the muscles of the arm and shoulder, and loosen the stone from his fingers. In all, from fifty to a hundred muscles must be contracted at nearly the same time.

The boy does not realize that he is using such a wonderful machine, or even that he is contracting muscles. He simply thinks, "I will throw the stone," and the brain gives the proper order to the numerous muscles. The message must be sent to each of these muscles at the same time, and must cause each to contract just the right amount. If the brain should make a mistake, and cause some muscles to contract too much or not enough, the stone would go wide of the mark. This really happens many times when the boy is learning to throw straight. We say that "practice makes perfect"; that is, the boy must learn how to throw the stone just where he wants it to go. In other words, the brain must learn how to make the muscles work in the proper way.

Number and Positions of the Muscles. — The fleshy part of our bodies is made up of a little more than two hundred muscles. They differ in size and shape. Most of them are fastened to at least two bones, so

that as the muscles are contracted the bones are moved. Figures 56 and 59 show how the muscles are arranged in the body, though comparatively few are represented here. The various muscles are so attached to the bones that they can be moved in all the directions that the joints permit. We can bend the arm or straighten it; we can move it to either side or turn it around, each motion being produced by a different set of muscles.


Fig. 59. — The Surface Muscles of the Body.

Muscle Growth. — It is a peculiarity of muscles that the more they are used, the stronger they grow. The blacksmith, because he constantly swings his heavy hammer, develops very strong muscles in his arms. When a person learns to ride a bicycle, he finds that certain muscles of his legs are weak, but, as he continues the exercise, the muscles become stronger, until he can climb even high hills without any great strain. One set of muscles, however, should not be developed and others

neglected. The man who has all his muscles moderately well developed is stronger and more healthy than the one who has highly developed his arm muscles without exercising equally the other muscles of the body.

If muscles are not used, they become small and weak. If a muscle were left idle for a few months, it would lose much of its power, so that we could not use it at all. Children in their active play ordinarily use all their muscles, so that they develop evenly. But as people grow older, certain muscles are used less and less. We take the trolley-car and the elevator to save the trouble of walking: as a result, we find that we cannot walk so far as we could a few years ago. We use the right hand in our work rather than the left, and the left hand is weaker and less skilful. We sit in a comfortable easy-chair until the muscles of the back are weakened, and as a result we cannot sit upright for any length of time without fatigue. Although we really want our bodies to be well developed and vigorous, we get into these habits of neglecting the muscles from carelessness.

Exercise. — It is worth our while to make special efforts to use *all* the muscles of the body. If we find that certain muscles are weak, those are the ones that we should take pains to exercise. Too frequently we do the reverse. If we find something that is particularly hard for us to do, perhaps sweeping or sawing wood, that is just what we should do every day, until the muscles are so developed that we find it easy work.

In large cities the chances that young people have

for muscular exercises are limited. For this reason gymnasiums have been erected in cities, and especially in schools and colleges. The person who commonly needs the most urgent advice to take exercise is the boy or girl who is ambitious to become a scholar. He prefers to spend all his time at his books, and is not willing to give even a little time each day to active exercise. He should remember that the person who studies all the time is likely to be outstripped by the one who studies and plays as well. Many students break down because they do not take sufficient exercise.

Out-of-door games afford the best possible exercise, since these not only develop the muscles but give the player fresh air and recreation at the same time. Such games as baseball, golf, and tennis are excellent. Bicycling is good exercise, though "century runs" and very fast riding are dangerous, and the habit of bending over the handle bars makes one liable to what is known as bicyclers' stoop. Brisk walking and running are very good exercise; strolling can hardly be called exercise at all, although in other ways a quiet walk in the open country is beneficial.

The royal maxim for perfect body development is: *A perfect body requires the development of all muscles; all powers unused are weakened.*

Stimulants. — Some people have the mistaken idea that they can increase their muscular power by the use of what are called *stimulants*, generally meaning by this some form of alcoholic drink. For a short time after a

person has taken the alcohol there may be a slight increase of muscular power, but a decrease of such power follows very soon, so that there is no real gain. If alcohol is used in any considerable amounts, there is a great weakening of muscular power.

The use of alcohol will unfit any boy for good work in an athletic contest. Under no conditions does alcohol used as a stimulant enable an athlete to do his best. It has a tendency both to weaken the muscles and to dull the senses. Boys and young men sometimes make the mistake of trying to "brace themselves up" for a contest by the use of alcohol. Professional athletes know enough to let alcohol alone under these circumstances.

QUESTIONS

1. Of what is the framework of the body made? What is this framework called?
2. What organs are inclosed in the skull?
3. How are the long bones of the arm and leg constructed?
4. Of what are bones made?
5. If we did not have enough lime in our food, what effect would it have on the bones?
6. How do children's bones differ from those of a grown person?
7. What happens to the bones if there is unnatural pressure upon them?
8. What are the results of wearing tight clothing?
9. How are broken bones repaired?
10. What is cartilage? Where is it found?
11. What two kinds of joints are there in the body?
12. How is a hinge joint made?

13. Mention all of the kinds of supporting and connecting tissues found in the body.

14. What is a ligament?

15. What is a tendon?

16. How does the ball-and-socket joint differ from the hinge joint?

17. How are the bones in a ball-and-socket joint fitted and fastened together?

18. Why do we have a hinge joint at the knee instead of a ball-and-socket joint?

19. Why do we need a ball-and-socket joint at the shoulder?

20. What is meant by dislocation?

21. What is a sprain?

22. What are the parts of a muscle?

23. How is a muscle contracted?

24. How is the muscle contraction controlled by the brain?

25. Why is it that a person falls over if he suddenly faints or dies, when in a sitting or standing position?

26. What effect have exercise and lack of exercise upon the muscles?

27. What are the best kinds of exercise?

28. Give some examples from your own observation of loss of power from disuse.

29. What is the effect of alcohol upon the muscles?

A LIST OF THE CHIEF BONES IN THE BODY

The nasal bones. The frontal bones. The parietal bones. The occipital bone. The mandible or lower jaw.	All forming the skull.
The sternum or breastbone. The ribs from the backbone to the sternum.	Forming the thorax.
The vertebræ forming the spine.	
The sacrum at the lower end of the vertebræ between the hips.	
The coccyx, a small piece of bone below the sacrum.	
The scapula or shoulder-blade.	
The clavicle or collar bone.	
The humerus, from the shoulder to the elbow. The radius and the ulna, from the elbow to the wrist. The carpals or wrist bones, eight in number. The metacarpals, from the wrist to the fingers. The phalanges or finger bones.	The arm.
The ilium. The pubis. The ischium.	Fused together to form the hip bone, or pelvic girdle.
The femur, from hip to knee. The tibia and fibula, from knee to ankle. The tarsals or ankle bones. The metatarsals, from ankle to the toes. The phalanges, or bones of the toes.	The leg.

CHAPTER VII

THE KIDNEYS AND THE SKIN AND THEIR DUTIES

WASTE PRODUCTS

Use of Food by Muscles. — A muscle is like a little steam engine which cannot work except when burning fuel. We have seen how the different foods are carried throughout the body by the blood. When these foods reach the capillaries, the muscle fibres take what they need for their use. The *proteids* serve especially to make new muscle tissue, which is constantly needed to take the place of that used up by the work of the muscle. The proteid or building foods are also needed to repair any injury that may have come to the muscle, and to supply the new material needed when the muscle is developing and growing. The *sugars* and *fat*, with some of the *proteids*, simply furnish heat and force; in other words, they are *fuel foods.* The food is *oxidized* in the muscles by means of the oxygen brought by the blood. As a result, *force* is developed to enable the muscles to contract, and *heat* is produced to warm the body.

Waste Products of Muscle Action. — When coal or other fuel is burned, or oxidized, smoke and gas pass off into the air and ashes are left in the grate. These

are *waste products*, because they are not used and cannot be used for heating. When the fuel food of the body is oxidized in the muscles and tissues, waste products are left, which are of no further use. These are carbon dioxide, water, and other substances. These waste products must be gotten rid of. We have already seen how the carbon dioxide is taken away by the blood, and breathed out of the body from the lungs. We know also that some water goes out in the breath. A larger quantity of water passes off through the skin and from the kidneys, as we shall see presently. The third waste product, known as **urea**, is taken from the blood by the kidneys, and finally leaves the body in the urine.

A large proportion of the food we eat is taken by the muscles to supply muscular force. Some of it is used in the brain, a small amount in the glands, and certain quantities in every active part of the body. But, although the uses made of the food may differ in the various places, the same oxidation takes place, and the same waste products always result.

Secretions and Excretions. — The materials produced by the body are generally classified under two heads. Those like carbon dioxide and urea are simply waste products and of no use at all. They are generally called **excretions**. But some of the materials are produced for special purposes. For example, the gastric glands in the stomach produce gastric juice to aid digestion, and the salivary glands produce saliva for the same purpose. Materials which are thus of use to the

body are called **secretions**, and they are generally produced by special organs called **glands**. We have already learned of several of these, the *salivary glands*, the *gastric glands*, and the *pancreas*.

The excretions are not only of no use, but if allowed to collect in the body they act as poisons. Hence they must be gotten rid of promptly. Some of them can pass off through the lungs in the breath, and some from the skin in perspiration, but some are disposed of in other ways. The urea in particular is eliminated by special organs.

THE KIDNEYS

Urea is thrown off from the body by means of a pair of organs called the **kidneys**. Each kidney is, in a grown

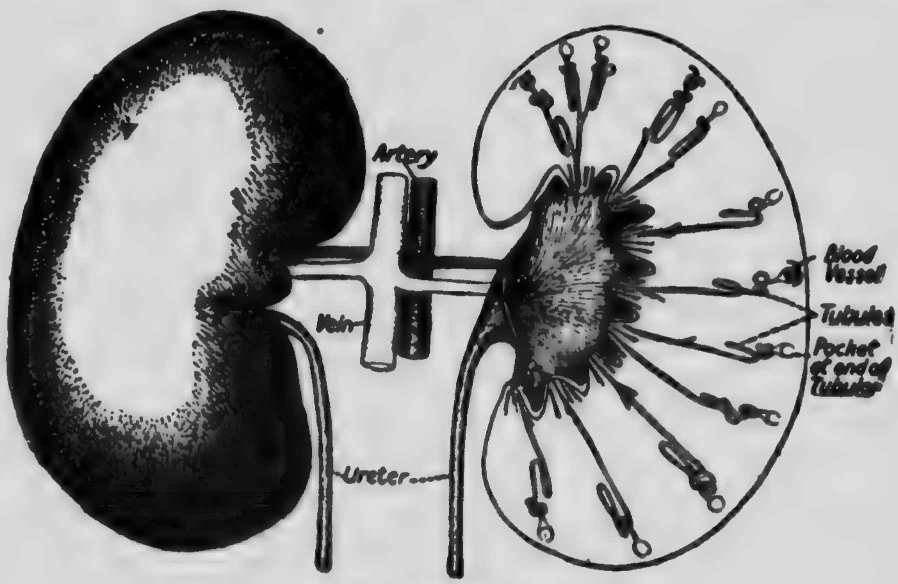


Fig. 60. — The Kidneys.

The one on the right is cut open to show the tubes which secrete the urea.

person, some four inches long and one and a half inches wide. The kidneys are located in the back part of the abdomen, just below and behind the stomach, and close to the backbone. Their shape is indicated in Figure 60. A large artery brings the blood to each kidney, as the same figure shows, and a large vein takes the blood away. There is also a tube, called the **ureter**, that passes from the kidney to the **bladder**, and takes away the material removed from the blood by the kidney.

The kidney is made up of a large number of blood vessels, together with a series of small tubes, called **kidney tubules**, as shown in Figure 60. As the blood passes through the kidney, the tubules take the urea and some other solid matters which are dissolved in the blood. This material, together with considerable water, which is also taken from the blood, is poured into the ureters, and passes to the bladder and then out of the body.

THE SKIN

Although mainly of use as a covering for the body, the skin has special duties of its own. It serves as a means for the passing out of waste and for regulating the heat of the body. A healthy skin is absolutely necessary if the body is to be in good condition. Sluggishness or improper action of the skin in its work is likely to cause sickness.

Structure of the Skin. — The skin is a thick sheet like a close-fitting garment, covering the entire body. A grown person has about sixteen square feet of skin.

The average thickness is about one sixteenth of an inch, though it is thinner in some places than others. It is thickest on the soles of the feet and the palms of the hands.

Fig. 61. — A Section of a Bit of Skin. Highly magnified.

If we take a thin slice of skin and look at it through a microscope, we find that it has two layers, one outside of the other, as shown in Figure 61. The outer layer is called the **epidermis**, and the inner layer is the **dermis**. We can stick a pin through the epidermis without feeling it, but the instant the point enters the dermis we feel pain. All the epidermis, except a thin layer on the inner side, is practically lifeless, and contains neither nerves nor blood vessels. The dermis is full of blood vessels and nerves, and is very sensitive.

The Epidermis. — The epidermis, though lifeless at the outer surface, is continually growing on the inside, where it is in contact with the dermis. Very often

when we look at our hands we can see one or more bits of loose skin which may be pulled off without harm. The outside skin is all the time being thus worn or rubbed off, bit by bit, and it keeps growing from the inside. The epidermis is so firmly attached to the dermis that the two are not easily separated. Occasionally we burn a spot on the finger, or are severely sunburned, so that blisters appear, that is, a little watery material has gathered between the epidermis and the dermis. If the blister is broken and the outer skin removed, the dermis is exposed. This is always sensitive and tender.

Thick Parts of the Epidermis. — A boy who is an enthusiastic ball-player is very proud of certain bunches on the palms of his hands, called *callosities*. The constant rubbing and striking of the ball causes the epidermis to grow more rapidly at these spots than elsewhere, and so it becomes thicker. Any part of the skin that has an extra amount of use grows thicker than the rest, this being nature's means of protection against injury.

If we wear tight or poorly fitting shoes that constantly rub the toes, round bunches called *corns* are formed by the thickening of the skin. We can prevent the growth of corns by wearing shoes large enough not to pinch the toes, and yet snug enough not to chafe the feet. It is difficult to get rid of corns after they have once formed, so it is wise to avoid the great discomfort which they cause by taking proper care of the feet. Children who go barefooted in the summer rarely have either corns or deformed toes.

Occasionally certain parts of the skin grow too thick, causing what are known as *warts*. Children are apt to be superstitious about these growths, because they come and go so suddenly. Some children believe that warts result from handling toads, and that they can be cured by the use of certain charms, both of which are absurd ideas. If a wart grows large enough to be really troublesome, it can be burned off with acid, but under ordinary conditions warts had better be let alone. They will disappear without assistance in time.

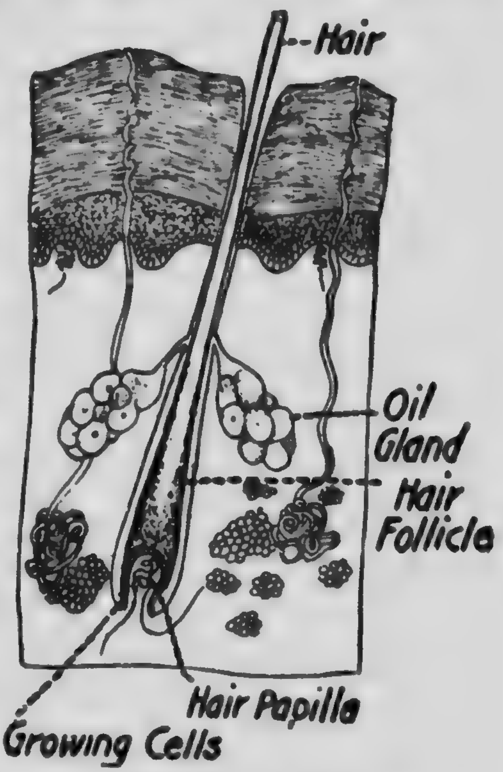


FIG. 62. — A HAIR.
Showing its root and follicle.

Hair. — Nearly all parts of the skin are covered with hair, which is an outgrowth from the epidermis. Figure 62 shows that each hair extends down through the skin into a little pocket. This is called the **hair follicle**. A very small mound, or **papilla**, which is the place where the hair grows, is located at the bottom of the pocket. The hair is thus constantly growing at its root, and being thus pushed out of the pocket. In other words, the hair grows from

the roots, not from the ends. If a hair is pulled out, the little mound at the root usually keeps on sending out more substance, so that a new hair grows to take the place of the old one. If the whole follicle, including the mound at the bottom, is destroyed, no new hair will grow.

Each hair is supplied with oil from tiny *oil glands*. These open into the follicle from the sides, as shown in Figure 62. They produce an oily substance that moistens the outside of the hair, keeping it soft and flexible. If the hair is brushed frequently, the oil will be distributed over it, so that no hair oil need be used to keep it in good condition. We should never brush the hair with anything but a soft hairbrush. Wire brushes are likely to scrape the scalp so that the follicles may be injured, and they may pull out the hair.

Hair is lifeless and has no sensations. If we place a hand upon the head, we may feel the touch, but the feeling is not in the hair itself; we feel the pushing of the hair against the nerves in the skin. We say that a cat's whiskers are very sensitive. The feeling is not in the hairs themselves, but in the very delicate nerves about the roots.

Hair grows on all parts of the body excepting the palms of the hands and the soles of the feet. In some places it hardly more than reaches the surface and is therefore so short that we do not notice it. Certain animals, like the cat and the dog, have very thick hair, which serves as a protection and covering for the skin. The hair of human beings is of no particular

use except for ornament and for its protection to the head.

The hair of the head has a tendency to fall out and produce baldness. This is especially true of the hair of men. Just why this is the case physicians do not know. Some think that it is due largely to the habit of wearing heavy hats with stiff rims which bind the scalp; they advise the use of loose, cool hats. Others are of the opinion that "shampooing" the hair with the aid of diluted ammonia and soap, or other substances, causes baldness. It is necessary, however, to keep the hair clean, and it may safely be washed with water containing a little soap. The soap should be carefully rinsed off and the hair thoroughly dried. Hair oil and hair restorers of all kinds should be avoided.

Toe Nails and Finger Nails. — The toe nails and finger nails are parts of the epidermis developed in a special way. Figure 63 represents a cross section of a finger, showing the nail. The purpose of the nails is to protect the fingers and toes. They also help to beautify the hand, and they aid us in picking up small objects by enabling us to grasp them firmly.

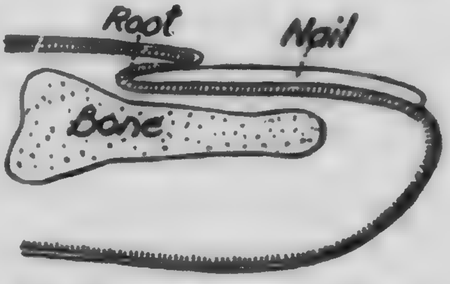


FIG. 63. — A SECTION THROUGH THE TIP OF THE FINGER. Showing the nail.

The nail grows outward from the root at the base, and unless the root is injured, the growth continues as

long as we live. The white "half moon" at the lower edge is where the nail is new and quite thin. If a nail is injured, it sometimes comes off. A new one will grow in its place, unless the root has been destroyed. We all dislike finger nails that are grimy or dirty at the ends. They should be kept clean and neatly trimmed with a knife or scissors. They should be cut only at the ends; neither the surface of the nail nor the skin covering e root should be scraped or cut.

Some young people form the habit of biting the nails. This is likely to injure the shape of the fingers, besides rendering the person disagreeable to all with whom he comes in contact. While various reminders may be employed to aid in overcoming the habit, such as some bitter substance placed upon the nails, the difficulty should be conquered by the exercise of will power.

The Dermis. — The dermis, shown in Figure 61, is thicker than the epidermis, and is very different in structure. It consists principally of a mass of fibres, running in every direction. The fibres are packed close together on the side next to the epidermis, but they are less dense near the muscles, which lie below the skin. Tiny fat cells are found between the fibres, as shown in Figure 61. The dermis is full of blood vessels, so that, when cut, it always bleeds. It is also very sensitive, because of the many nerves it contains. Some of these nerves are particularly sensitive to heat and cold.

FUNCTIONS OF THE SKIN

As a Protection. — The epidermis is made of flat, scalelike cells, packed together so closely that they are a very great protection to the flesh beneath. Some of the cells may be seen in Figure 61. We can plunge the hand into poisons without injury, because the substances cannot quickly make their way through these cells. Some diseases, as we shall see later, are caused by microscopic living germs getting into the body and growing there. The epidermis helps to protect us from such diseases by keeping out the germs. If they get through the skin, they may produce sores, boils, abscesses, or even more serious troubles. They cannot pass through the healthy epidermis, but often a slight scratch or bruise breaks the skin enough to let the germs in. As a result of the growth of these germs, the scratch becomes inflamed and painful, or perhaps develops a sore or boil. If the germs can be kept out, these sores will not appear. Special care should be taken to *wash all cuts and bruises*, and to cover them with a plaster or bandage so as to prevent bacteria from entering where the epidermis has been broken.

As an Excreting Organ. — When we have been taking vigorous exercise, or on a very warm day, small drops of moisture, or *sweat*, appear on the forehead, the nose, and other parts of the body. This moisture is secreted by the *sweat glands*, of which we have about two and a half millions in our skin.

A sweat gland is too small to be seen with the naked eye, but it consists of a tube passing through the epidermis, and coiled up in a knot on the inside, as shown in Figure 61. This tube secretes the sweat, which passes out through a minute hole in the epidermis, called a **pore**, and is discharged upon the surface of the skin. The skin of the whole body is covered with these tiny

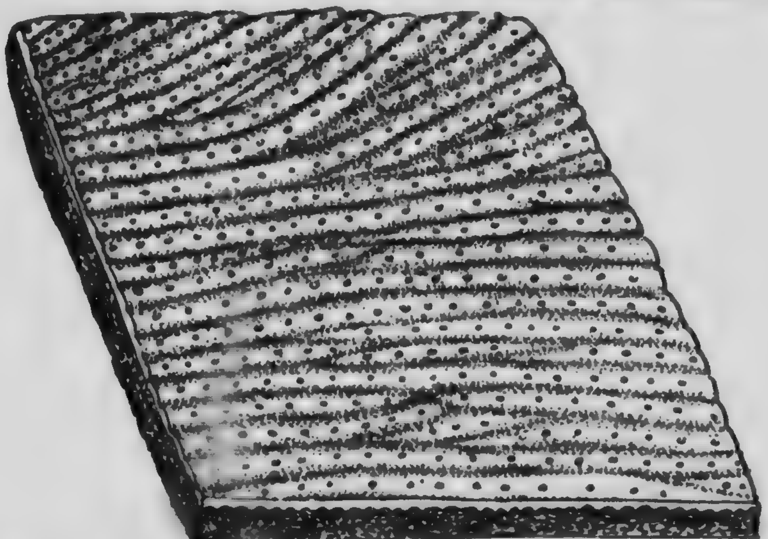


FIG. 64. — A BIT OF SKIN AS IT APPEARS UNDER A MICROSCOPE. Showing furrows and pores.

pores, each leading into a gland. Though they are found all over the body, there are more of them upon the forehead, the palms of the hands, and the soles of the feet than elsewhere. If we look at the skin of the fingers, we see that it is covered with irregular furrows. If we compare two fingers, we find that the furrows are unlike. The pores in the skin of the fingers are along the ridges between these furrows, as shown in Figure 64; they may be seen with a magnifying glass.

We notice the sweat only when it appears in drops upon the surface of the skin, or when it moistens the clothing. It is then being poured out of the glands in especially large quantities, but the glands are bringing it out all the time. The sweat is usually evaporated as fast as it comes to the surface, not becoming visible, but simply moistening the skin. If we hold the fingers close to a cold window pane, vapor collects on the glass. This shows that water is evaporating from the fingers, even though sweating is not apparent.

The sweat itself is principally water, though small amounts of salt and other substances are dissolved in it. In fever, sweating is reduced very much or stops entirely.

As a Regulator of Body Temperature. — The air, both in doors and out, is usually cooler than our skin. The air is constantly taking heat from the skin, cooling it and the blood which flows near the surface. The faster the blood flows through the skin, the faster it is thus cooled by the air.

We have already seen that the skin is full of small blood vessels. These, like all the rest of the blood vessels, can be expanded and contracted as is needed. If the body is producing more heat than usual, the brain causes the blood vessels in the skin to expand; the blood then flows faster, and more blood is cooled. If the body is not producing as much heat as usual, these blood vessels are made to contract. The blood is thus kept away from the surface and does not lose its heat by giving it out to the air. By opening and

closing these blood vessels, the brain is able, without our knowledge, to increase or decrease the amount of heat lost through the skin. In this way our temperature is controlled very closely and accurately. If the body is too warm, the blood vessels expand and let the heat out; if too cold, they contract and keep it in.

The nerves that are sensitive to heat and cold are located in the skin. When the warm blood pours through the skin, it warms these nerves and we feel the heat. When the blood vessels contract, so that the warm blood is kept away from the skin, these nerves are cooled by the air outside, and we feel cold. On a warm day we feel hot, not because the body is warmer than usual, but because the warm blood is flowing over the heat nerves in the skin. The body has practically no sensations of heat and cold except those in the skin and in the lining of the mouth and the digestive canal.

Cold-blooded Animals. — Frogs, snakes, and certain other small creatures are called *cold-blooded animals.* The amount of heat produced in their bodies is not very great, and it passes off as fast as it is formed. The cold-blooded animals are never much warmer than the air about them. On a warm day they may be very warm, on a cold day they will be cold. Such animals are usually rather sluggish, especially in cold weather.

Warm-blooded Animals. — The amount of heat produced in our own bodies, and in those of such animals as dogs, cats, and horses, is comparatively large. This heat warms the blood to a certain temperature, which

does not change with the temperature of the air, but remains about the same all through life. We call animals whose bodies keep the same temperature *warm-blooded.* Their blood is usually warmer than the air, although on a hot summer's day the air may be the warmer.

To keep the blood at this temperature requires considerable activity and a large amount of food, just as a considerable quantity of coal is required to keep our rooms very warm in winter. A cold-blooded turtle may live for six months without eating a mouthful; its activity is so slight that the small amount of food stored in the body is enough to sustain life, and no heat is needed to warm the body. A warm-blooded animal, on the other hand, must not only have a large supply of food, but it must have this food more or less regularly, and it can live but a short time if deprived of the regular supply.

When we are in perfect physical condition, the temperature of our bodies is almost exactly 98½° F. If the temperature rises above this point or falls below, it is commonly an indication of ill health. We feel so much warmer on a hot summer afternoon than we do on a winter morning that it seems to us the temperature of our bodies cannot be the same, but a test with a thermometer would show, in both cases, just the 98½°, if we are well.

Some warm-blooded animals — bears, for example — sleep throughout the winter. When thus asleep they burn less fuel (food) and do not keep warm; their body

temperature falls very much, but this does them no injury. When they wake in the spring, they begin to burn food more rapidly and are soon warmed again. Such animals are called *hibernating* animals.

Regulation of Heat by the Lungs. — The skin is aided in regulating heat by the lungs. As our bodies are always producing much more heat than is needed to warm them, a large proportion of this heat must be given out, in order to keep the proper temperature. Much of the extra heat passes off in breathing. If we take in a breath of cool air and then breathe it out close to the back of the hand, we find that it is much warmer. The warm blood passing through the lungs has heated the air, and the blood is correspondingly cooled. The amount of heat which the body loses in breathing differs very greatly on different days. In winter the cold air may take much heat from the blood in the lungs.

Sweating as a Means of regulating Heat. — In summer the air may be about as warm as the body, and in this case no heat at all would be lost through either the lungs or the skin by simply warming the air. In hot weather, therefore, another means of getting rid of the extra heat is provided. If we wet a finger and blow upon it gently, or hold it in the wind, the finger feels cool. The water is evaporated by the wind, and it takes a large amount of heat to evaporate water. The heat required to evaporate the water on the finger is taken from the finger itself, leaving this somewhat cooled. In the same way the sweat that is poured out upon the skin is evaporated, taking heat from the body

and le ng this correspondingly cooler. The more we perspire the more the evaporation of the sweat cools our bodies.

The sweat glands are connected with the brain through nerves, and when the body has too much heat a message from the brain makes the glands begin to secrete sweat profusely. The sweat is rapidly evaporated, and in this way we get rid of the extra heat that would make the blood too hot, if there were no way of escape. The evaporation of the sweat takes so much heat that the body is kept at its ordinary temperature, no matter how warm the day may be.

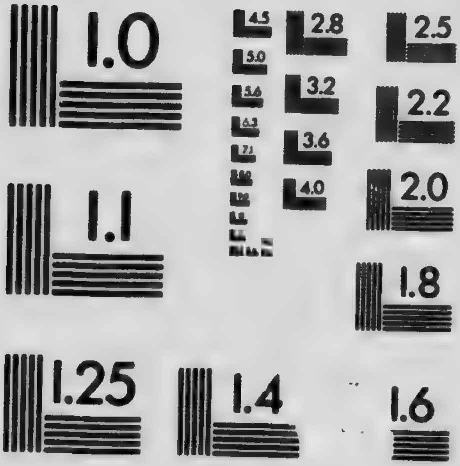
Dogs do not sweat very much, and are apt to suffer greatly from the heat of summer. By their rapid breathing, or *panting*, they take in large quantities of air, which, passing through the lungs and taking heat from the blood, helps to keep down the temperature of the body.

"Taking Cold." — There are people who seem to take a certain pride in their sensitiveness to drafts, and who are always ready, and expecting, to "take cold." Such persons usually do take cold oftener than other people, because they wrap their necks closely when out of doors, and in the house they sit near a register or with shawls about the shoulders if the air of the room is a bit chilly.

Now "taking cold" is a habit which may be almost wholly avoided, if we will learn to treat the skin properly. In the first place, colds are not due to exposure to cold. Explorers do not take cold when in the Arctic regions,

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



although they may do so after their return home. Soldiers can sleep on the damp ground or may be out in the rain for days at a time without catching cold. People who live out of doors seldom suffer from colds. We may *feel cold* from such exposure, but we do not *take cold.* We know from experience that we can have the face and the hands exposed when the temperature is very low, without catching cold.

Yet it is true that we do sometimes suffer this disagreeable malady if cold air strikes some part of the skin which is usually protected. A slightly cool draft striking the bare shoulders may be sufficient cause. This fact has given rise to the idea that the best way to prevent taking cold is to protect the neck and shoulders by means of extra wraps. This is a wrong method. If we should cover our faces with wraps in the same way, they would soon become so tender that drafts striking them would produce colds. If, on the other hand, we should expose the neck as we do the face, it would soon become so accustomed to changes in temperature that it would be as impervious to cold as is the face. It is, then, very unwise to get into the habit of wearing furs or mufflers around the neck, or of turning up the coat collar about the ears. The extra protection may be necessary for comfort on an occasional extremely cold day, but the more we wrap the neck the more sensitive it becomes, and consequently the more liable we are to take cold.

QUESTIONS

1. What are the three waste products of muscle action?
2. What becomes of each of these waste products?
3. What are excretions and secretions? Is sweat a secretion or an excretion?
4. What organs produce secretions?
5. Mention as many kinds of secretions as you can.
6. What is the duty of the kidneys?
7. How are the kidneys constructed?
8. What are the two parts of the skin?
9. Where is the epidermis, and what are its characteristics?
10. What are callosities and corns? Can callosities and blisters both be produced by rubbing? How?
11. What are the parts of a hair?
12. How should we take care of the hair?
13. What are warts?
14. How do the toe and finger nails grow? Have the nails any sensations?
15. What is the structure of the dermis?
16. How does the skin act as a protection?
17. What are the sweat glands?
18. How is the heat lost through the skin?
19. What are cold-blooded animals?
20. If a cold-blooded and a warm-blooded animal were placed in an ice box, what effect would be produced on each?
21. How is the heat of the body regulated by the lungs?
22. Why do we need sweating to aid in regulating body heat?
23. How may we avoid taking cold?

CHAPTER VIII

THE CARE OF THE SKIN

THE skin, as we have learned, is an organ of great importance to the body. It is important as a protecting organ, as an organ of excretion removing waste products from the body, and it is at the same time the chief organ concerned in regulating the temperature.

BATHING

Cleanliness. — In order that the skin may keep in healthy condition, it is necessary that the sweat glands be kept free and open. The fat glands connected with the hairs constantly pour oil upon the skin, and the sweat glands secrete considerable solid material with the sweat. These substances remain upon the skin, and unless they are frequently removed they will in time clog the pores, and will also give to a person an unpleasant odor which renders him disagreeable to those about him. Frequent bathing and washing of the body is therefore desirable. No positive rule can be given as to the frequency with which we should bathe. A daily bath is advisable, although it is not essential to health.

Cold Baths. — Cleanliness is not the only reason for bathing. The bath stimulates the skin, and this would

render it of value even if it were not required for purposes of cleanliness. We have seen how the delicate blood vessels expand and contract with changes in temperature. The muscle fibres of these blood vessels and the nerves controlling them need exercise as much as do the other muscles of the body. Our habits of life give them little chance for this needed exercise; we keep our rooms uniformly warmed, and when we go out of doors on a cold day we cover all parts of the body except the face. Under these conditions the blood vessels in the skin are likely to become sluggish, and they need stimulation. The simplest way of giving this is by means of the cold bath.

Effects of a Cold Bath on the Skin. — A cold bath, whether a plunge in cold water, a shower bath, or merely a sponge bath, has always with a vigorous person the same effect. At first there is a sensation of cold, which causes the blood vessels to contract. For a short time the skin may be white and cold, but this is presently followed by what is called the *reaction.* The blood vessels open once more, allowing the warm blood from the interior to flow rapidly through the skin. The skin becomes flushed and warm, and there is a feeling of exhilaration, due to this after glow.

A person should leave the water while still under the influence of the reaction. If he stays longer, he becomes chilly again, and will remain cold and uncomfortable for hours. The length of time the after glow lasts depends upon the person, the temperature, and the water. It remains longer with salt water than

with fresh. The greater the after glow, the more beneficial is the bath. If the body is rubbed vigorously with a rough towel after the bath, the glow is much increased, and the benefit correspondingly greater. Indeed, vigorous friction with a towel is of fully as much benefit as the bath itself.

The expansion and contraction of the blood vessels thus brought about furnishes the skin with the needed exercise. If a person lives out of doors, exposed to all sorts of weather, such exercise is not necessary; but to people spending most of the time in the house, such a bath is to the skin what the gymnasium is to the muscles. A warm bath does not accomplish the same purpose. It frequently makes one tired instead of exhilarated, and should therefore be taken only after the work of the day is done, instead of in the morning.

Sometimes women and young girls who have not a great amount of vitality find that the cold plunge, or even the cold sponge bath, fails to give the desired reaction. In such a case the body should be accustomed to the cold water gradually. Little by little the space covered by the cold water may be extended until the skin has become sufficiently toughened so that the bath may be made general. This may usually be accomplished in the course of half a dozen mornings. To become accustomed to the cold plunge it is best to begin with slightly warm water, using it a little cooler each day, until we find we can endure water which is really cold. All young persons will find in the cold bath, either plunge or sponge, a source of pleasure

which, after they have become accustomed to it, the warm bath cannot give.

Cold Baths a Protection against Colds. — This skin exercise renders the cold bath a protection against colds. If we will accustom ourselves to a cold sponge bath every morning, and will avoid covering the neck with thick wraps, we are much more likely to escape the habit of taking cold. The person who, by means of heavy wraps, protects his skin from exposure, and who takes only warm baths, is pretty sure to get into a condition that favors taking cold. He then regrets that he "takes cold so easily." The remedy may be in his own hands. It consists in adopting a mode of life that will give his skin the needed exercise.

Hot Baths. — We can easily test the difference in effect of the cold and the hot bath. If we bare the arm and pour cold water upon it, then rub it briskly, the skin becomes red and warm with the after glow. If we plunge the arm into water as hot as can comfortably be borne it first grows red, then turns white, and there is no after glow. There are times, however, when a hot bath is beneficial. It may enable one who is restless and wakeful to go to sleep, since it draws the blood from the brain. When we feel a cold coming on, a hot bath or even soaking the feet in hot water may draw the blood from the throat and nose sufficiently to prevent the cold from developing. An occasional hot bath is also desirable for the cleansing of the body, even though cold baths are frequently taken.

CLOTHING

We should remember that we wear clothing for the purpose of comfort or adornment rather than to protect us from taking cold. For comfort it is necessary, in cold weather, to cover the body very completely with clothing. We should remember, however, that the clothing does not warm the body, but simply holds in our body heat, keeping it from passing off by way of the skin. Any clothing that conducts or sends off heat rapidly will cool the body quickly. Clothing that conducts heat slowly will keep the body warm. Linen and cotton carry the heat away rapidly, while woollen clothing holds it back. We should therefore wear linen or cotton garments in the summer time, and woollen clothing in the winter. Coarsely woven cloth, which is filled with air spaces, carries the heat away very slowly. Clothing made of such material is, then, the very best for keeping the body warm in cold weather. Similarly, two light garments, worn one over the other, are warmer than one heavy one of equal weight. The air space between the two acts as a "non-conductor" of heat.

When we sleep, our bodies should be more warmly covered than when we are awake. A good rule to keep in mind is that for sleeping the feet should be warm and the head cool. As the body, during sleep, needs rest as much as possible, it ought not to be compelled to keep up any extra amount of heat. Paper is a material which readily holds back heat, and if a couple of newspapers be placed between two pieces of bed clothing

they do as good service in keeping the body warm as a blanket.

BURNS

Burns are very common injuries to the skin and are often very serious. In case of a slight burn we can usually relieve the pain for a time with cold water. One of the best applications for a burn is a paste which can be quickly made by rubbing *soda* or *baking powder* into some *vaseline* or *sweet oil.* Place this paste, which should be thin enough to spread easily, on a clean cloth and apply it so that it shall completely cover the burn. Another method is to apply a cloth wet in a solution of *baking powder* or *saleratus* and *water.* This solution is, however, less soothing than the paste, and the cloth must be soaked in it frequently. The burn should always be protected from the air. This may be done in an emergency by applying *linseed oil, lime water,* or even *flour,* to the place, but no cotton wadding should be put on the wound or anything else that might leave little particles on the surface. If the burn is neither very deep nor very extensive, it will heal readily; but if it is severe, it should be cared for by a physician.

Life might sometimes be saved if people would remember what to do in case the clothing catches fire. If the clothing gets afire, one should catch up any woollen article that may be at hand, wrap it closely around the burning clothing, and immediately lie down flat upon the floor or the ground, and roll over and over. Without air the fire cannot burn, and the rapid rolling,

even if one cannot reach any woollen stuff to serve as an extinguisher, will usually put out the fire. People have lost their lives by standing up while attempting to remove burning clothes. The flames rise, and if the person is standing, he is very liable to breathe the fire into his lungs. This causes almost instant death.

If a person whose clothing is on fire loses his wits and starts to run, he should be thrown down as a means of saving his life, for running is very dangerous. He should then be wrapped in a rug, a blanket, a coat, or any similar heavy article that may be at hand, to smother the flames. After the fire is out, if the flesh of the person is burned, the clothing must be removed. Care must be taken, however, that the skin is not torn off. The clothing is likely to stick to the skin, and if it does so, it should be allowed to remain, at least where it adheres, the cloth being cut off around the place if necessary. If there are blisters, they should be opened and the liquid pressed out. Any further treatment should be given by a physician.

FROSTBITES

The freezing of fingers, toes, nose, or ears is not an uncommon occurrence on an extremely cold day. In such a case, the water in the blood and the muscles is actually turned to ice. If the frozen parts are thawed out slowly, no permanent injury may result; but if they are thawed rapidly, serious trouble may follow, which may render amputation of the toes or fingers necessary. For this reason frostbites should be *thawed*

slowly. Rubbing the frozen parts with snow or cold water is recommended. This will thaw them out with the least possible danger of injury. In general, to preserve a part of the body that has been frozen, it must be promptly but very gradually thawed. After the thawing has been completed, the person may be warmed and given hot coffee or some other warm drink.

Many people wrongly suppose that the uncomfortable affection of the feet known as "chilblains" is the result of frostbite. They are really due to getting the feet very cold and then warming them too quickly, and do not appear in children with a vigorous circulation. Warming cold feet over a register or in a stove oven is very likely to cause the difficulty. The best way to protect the feet against chilblains is to wear warm stockings and thick shoes in cold weather, and give the feet plenty of exercise.

QUESTIONS

1. Why should the sweat glands be kept free and open?
2. What is the use of sweat?
3. What is the effect of the cold bath?
4. What are the advantages of the cold bath?
5. How do cold baths act as a protection against colds?
6. What is the difference in effect between the cold and the hot bath?
7. What clothing is most suitable for summer? For winter?
8. Are silk underclothing and stockings as useful as woollen? Why?
9. Why should the body be warmly covered during sleep?
10. What should be done when a person's clothing catches fire?
11. What should be done for frostbite?

CHAPTER IX

STIMULANTS AND NARCOTICS

Many people have the habit of using certain substances which interfere with the health of various parts of the body. These substances are of two general classes, known as *narcotics* and *stimulants.*

By a **stimulant** we generally mean a drug which, on being taken into the body, excites an unusual activity. A substance may be a stimulant, even though it is a poison. Strychnine, for example, though a violent poison, may in small quantities act on the body as a stimulant, exciting it so excessively that a slight breath of air may throw the person into convulsions.

Narcotics have just the opposite effect. They soothe and dull the actions of the body, and have a tendency to put people to sleep. Although narcotics and stimulants seem thus to be very different, no sharp line can be drawn between them. The same drug may produce both effects, its first effect being that of a stimulant, while its later and more lasting effect is that of a narcotic. When such a substance, alcohol for example, is taken in a small amount, it seems at first to produce a stimulating effect, but it also produces a narcotic effect which may not at first be noticed. When a larger quantity is taken, the narcotic effect is unmistakable.

OPIUM

Opium is one of the most dangerous of narcotics. *Morphine* and *laudanum* are two common forms of the drug. *Paregoric* and *soothing syrup*, both of which contain opium, are especially dangerous, and should not be given to children. Opium dulls the senses and finally puts a person to sleep. The reason why it is so dangerous is that it has a tendency to produce a terrible *craving for opium.*

A person begins by taking a small amount, possibly prescribed for him by a physician as a remedy for toothache, headache, or neuralgia. The drug not only soothes the pain, but produces a pleasant, restful feeling. Whenever the person has a pain which he wishes to relieve, he uses the same remedy, or he even imagines the pain for the sake of taking the drug. Soon the small doses with which he began cease to produce the desired effect, and he takes larger amounts. Before he suspects the fact, he has become an "opium eater," and no longer even pretends to make the excuse that he takes the drug as a medicine.

Opium destroys the ability to think clearly and ruins the moral nature. The opium eater frequently becomes a liar and a thief. His health is undermined. He no longer finds pleasure in work or in recreation, and after a while even the drug itself ceases to give him relief or satisfaction. The use of the drug so affects his will power that when he finds himself a slave to the habit he has not the strength of will to restrain the appetite.

When once the terrible habit has obtained a hold upon a man, it is almost impossible for him to control it. The use of opium in any form, except under the direct advice of a physician, is consequently exceedingly dangerous. Many physicians are unwilling to prescribe it, knowing as they do how easily the habit is formed.

The use of *chloral* and *cocaine* is equally dangerous, the effects being similar to those of opium.

TOBACCO

Tobacco is a milder narcotic than opium, and one much more widely used. Tobacco contains a poison which is deadly when taken in considerable quantity. It is a question whether the amount of this poison taken into the body by a grown person who smokes but little is enough to produce injury. There can be no question about the ill effects of tobacco on young people, however moderately it may be used. Used freely, it is undoubtedly injurious to adults.

Moreover, mild narcotics like tobacco share with the stronger narcotics, though in less degree, that power of making the user want more and more of them. There are many other excellent reasons for refraining from the habit of using tobacco.

1. Tobacco is of absolutely *no value* to the healthy body. It neither acts as a food nor does it serve any other useful purpose.

2. The use of tobacco by young people may *check the*

proper growth and development of the body. Careful study of college students has shown that those who are addicted to the use of tobacco are, on the average, considerably less developed than those who let it alone. The tobacco habit handicaps a boy in his physical development at the very start of life.

3. The use of tobacco temporarily *reduces one's muscular power.*

4. Its excessive use by young people often causes *heart trouble.* The "cigarette heart" is well known to physicians. Brain difficulty, insanity, and even death are sometimes traceable to tobacco.

5. It is *an expensive habit.* The money spent for tobacco could certainly be put to better use, and could be employed in ways that, to a young person at least, would give more pleasure and profit.

6. It is a habit that renders one *disagreeable to others* and tends to selfishness. Most people who do not use tobacco, women especially, find the use of it by their acquaintances very disagreeable. Its use sometimes tends to selfishness and to a disregard of the feelings of others.

7. The use of tobacco is likely to lead boys into *injurious company,* inviting them to idleness and to other bad habits.

Of all forms of tobacco, cigarettes probably do the greatest amount of injury. A person who uses cigarettes is likely to "inhale" the smoke. This means breathing the smoke into the lungs, which is far more injurious than simply taking it into the mouth. Boys

in particular should know this, for cigarettes are generally used by them on account of their cheapness.

For these reasons the wise course is to leave tobacco alone.

ALCOHOL

One of the greatest dangers that a young person has to meet is that of acquiring the *alcohol habit.* Fortunately, it is not so common as the tobacco habit. Nevertheless, it has destroyed the lives of hundreds of thousands of young people, and has been a stumbling block in the way of hundreds of thousands of others. It has led to countless crimes, and has caused an inestimable amount of poverty and suffering. The use of alcohol is particularly dangerous, because it frequently obtains a mastery over young people without their realizing the fact.

The Use of Alcohol in Excess. — The effect of alcohol upon the body depends largely upon the amount used. When speaking of the use of alcohol in excess, people usually mean its use in quantities sufficient to produce intoxication, or with a frequency that keeps the person more or less under its influence. The use of alcohol in such quantities is disastrous to health. It injures the action of the heart, interferes with circulation, and impairs the digestive powers. Moreover, it has a very important influence upon the moral nature. The drunkard loses his sense of responsibility and ceases to be a normal man. His whole body becomes diseased and unable to carry on its proper functions. His

mind becomes dull and his ambitions disappear. The use of alcohol in large quantities destroys a man's chance of the highest success. Alcohol causes the death of thousands of men and women every year.

Use of Alcohol in Smaller Quantities. — When alcoholic drinks are used in quantities insufficient to produce intoxication, their effect upon the body may also be serious, although not always apparent. The injury is so gradual that there may be little to call attention to it. Some people use wines or beers in small amounts for years without being apparently injured by them. Nevertheless, alcoholic drinks, when habitually used, even in small quantities, frequently produce decidedly injurious effects. They are never needed by persons in health, and they are certainly dangerous to all young people.

The effect of using alcohol in small quantities does not appear at once. Its action when so used was shown recently by a series of experiments upon dogs, made by Dr. Hodge, of Clark University. Four dogs were selected from the same litter, all as nearly alike as possible. Two of them were given only ordinary food. The other two were treated in exactly the same way, except that they were given a small amount of alcohol with each meal. They were never given alcohol enough to make them intoxicated, and, taking into consideration the relative size of the dogs and a man, the amount given was relatively about as much as would be taken by many moderate drinkers. At first the four dogs were practically alike, but little by little differences began to appear between those that

were given the alcohol and those that had nothing but the regular food.

In the course of a few months the "alcohol" dogs were quite inferior in appearance to the other two. By the end of a year and a half the difference was very marked. The "alcohol" dogs were sleepy, and had a general appearance of worthlessness. They were less active than the other dogs, and were much more quickly tired out. They would not bring back a ball when it was thrown for them so often as the others, and they frequently lay down to rest. In other words, the use of alcohol had lowered the intelligence, the brightness, and the muscular power of the dogs.

If a moderate use of alcohol affects dogs so much in eighteen months, we may be sure that it has some injurious effect on the people who continue its use in this way for years. Whatever success in life has been made by a man who is a moderate drinker, he would certainly have amounted to as much without the alcohol, and perhaps a great deal more.

Competition is so great in these days, in business, in the professions, and, in fact, along every possible line of work, that the boy or young man of the present day needs to have every possible power of mind and body at his command. The man with clear and unimpaired brain, with a healthy, well-cared-for body, with body and brain controlled by a determined, resolute will — he is the man who will make a success in the coming years of the twentieth century.

The Alcohol Appetite. — We have already learned that

one of the most dangerous things about alcohol is its tendency to *create a desire for more.* This desire may be very slight at first, but it is likely to grow. Moreover, although at first a small amount of alcohol is all that a person wants, or can drink, when his body becomes accustomed to this amount, he almost without knowing it takes a little more. Quite unconscious of how serious a thing it is, he slowly increases the amount used, sometimes by taking a larger amount of weak liquors and sometimes by taking stronger ones. He begins with beer and finally uses distilled liquors. The appetite grows with indulgence, and sooner or later it may become so firmly fixed that he is quite unable to break it.

Danger of the Appetite. — The fact that the appetite grows slowly and imperceptibly is what makes alcohol so dangerous. If a boy or young man could appreciate how the appetite is increasing, if he could realize to what it is likely to lead him, and if he could understand at the beginning how he is slowly becoming bound by a habit, he would in most cases curb the habit before it developed much strength. But the habit grows imperceptibly, and at the same time undermines his will, until it finally produces disastrous results.

The continued use of alcohol, moreover, is likely to crush out all desire to reform. The alcohol appetite might be overcome in most cases if the person had a sufficiently strong desire to do so; but his will power and his desire for a better life are taken away as the appetite grows upon him.

While it is true that some people use alcohol in small amounts without becoming mastered by the habit and without developing an alcohol appetite, it is equally true that with thousands of others the small amount of alcohol that is taken at first leads to the development of an appetite. It is never safe for a boy to run the danger of developing such an appetite. He may not become mastered by it, but experience has shown that in many cases the boy finds himself in time mastered by the habit. It is never possible to predict what will be the result. Drunkards are commonly made out of boys and girls who do not intend to use enough alcohol to injure them. If a boy never begins to use alcoholic liquors, he will never become a drunkard; but if he does begin, even in a mild way, he places himself among those from whom drunkards are made. The only sure way to avoid this danger is to avoid its beginning, and, in avoiding that, the boy also insures for himself a healthier body, a clearer brain, and a better chance for success in life.

QUESTIONS

1. What is the difference between a stimulant and a narcotic?
2. What is the effect of opium, and why is it a dangerous drug?
3. Why should tobacco not be used?
4. What is the effect upon the body of using alcohol in excess?
5. What are the probable effects of a moderate use of alcohol?
6. What do you regard as the strongest reason for avoiding alcoholic drinks?

CHAPTER X

THE NERVOUS SYSTEM

EVERY large factory must have a superintendent. Otherwise the persons employed to do various tasks would work independently of one another, and as a result little would be accomplished. The superintendent is indeed the most important man in the entire factory.

Within our bodies various actions are going on. Over two hundred muscles, numerous glands, and many other organs are constantly at work. If they should act independently there would be great confusion. In our bodies, however, as in the factory, there is a superintendent, whose duty it is to control all the different parts and keep them working in harmony with each other. A few of the body actions, like the beating of the heart, can take place without direct command from the superintendent, but with the others the order of the superintendent is required before the organs will work at all.

The muscles will never act unless they are commanded to do so by the central controlling organ. As we have already learned, the organ that corresponds in the body to the superintendent of a factory, and that controls the numerous activities, is the **brain.**

The brain is connected with every part of the body by a series of **nerves.** This is the organ with which we think, and by means of which we *will* to do anything. The brain also causes a great many actions to take place in our bodies without any knowledge on our part. We do not realize, for instance, that the brain is constantly sending messages to the blood vessels of the skin, causing them to open or shut.

THE BRAIN

The **brain** fills the bony box called the skull. Figure 65 shows its shape and structure. It is a very large

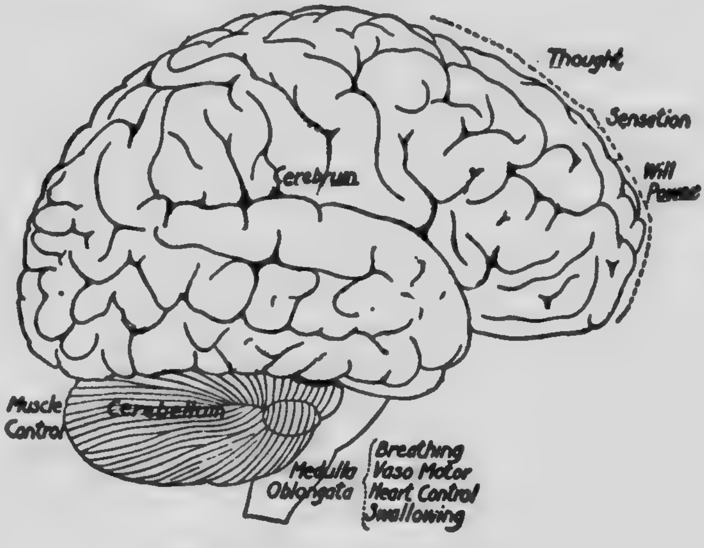


Fig. 65.—The Human Brain.

organ, that of an adult weighing some three pounds. There is considerable difference in the weight of various brains. The more intelligent races commonly have large brains, while those of less intelligence usually

have smaller ones. There are, however, among individuals, some remarkable exceptions to this general rule. The brain, as we may readily believe from its wonderful powers, is a very complicated organ. It is divided into three main parts, as may be seen from Figure 65.

The Medulla Oblongata. — Forming the very lowest part of the brain is the **medulla**, or medulla oblongata, which lies between the spinal cord and the main part of the brain. It is very small, not more than one and a quarter inches in length, and yet it controls some of our most important body actions. As Figure 65 indicates, the *breathing*, the *vasomotor* system (*i.e.* expansion and contraction of blood vessels), the *heart control*, and *swallowing*, together with other functions, are the special care of the medulla.

The Cerebellum. — A little higher than the medulla is situated a larger rounded part of the brain, about half as large as a baseball, called the **cerebellum.** It is somewhat flattened and, as Figure 65 indicates, is marked with numerous furrows. It lies over the medulla. The cerebellum is thought to influence *muscular action.* We have seen how wonderfully the muscles are adjusted so as to act together, as, for instance, when a boy throws a stone. This is supposed to be accomplished in part through the action of the cerebellum.

The Cerebrum. — The **cerebrum** is the largest part of the brain. Figure 65 shows that it is covered with deep furrows which divide it into folds called *convolutions.* These folds are not exactly alike in all brains,

though the larger ones are almost always present. The cerebrum is divided by a very deep furrow into two parts, called the *right* and the *left hemispheres*. The division is indicated in Figure 66. The two parts are connected with the body in such a way that the right hemisphere controls the left side of the body, and the left hemisphere the right side of the body. The cerebrum is the part of the brain that is active in thought and in the exercise of will power. What we call the "mind" is centred in the cerebrum. It is the centre which starts and controls the activity of the body.

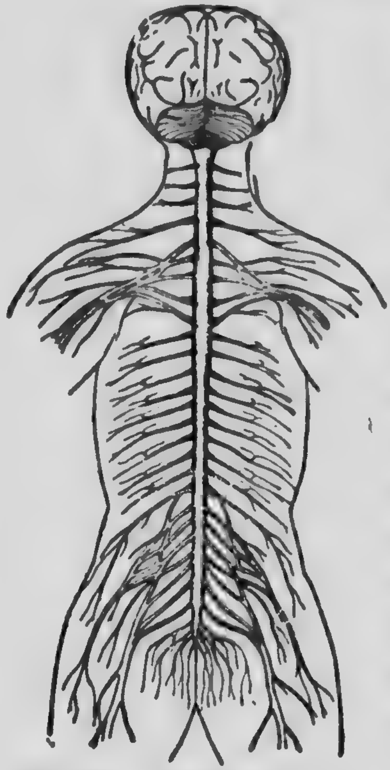


FIG. 66. — THE NERVOUS SYSTEM.
Showing the brain and the spinal cord with its nerves.

THE SPINAL CORD

A long, soft, white cord, called the **spinal cord**, starts from the lower end of the medulla (shown in Fig. 66), and passes down through the backbone or **spine**. The vertebræ of the backbone protect the cord on all sides. In other words, the spinal cord runs inside the backbone (see Fig. 42, p. 125). As may be seen from Figure 66, the cord is not of the same thickness throughout its length, but it becomes gradually smaller as it passes down the back. At the lower end it divides into fine

threads. When in its proper position inside the backbone, the cord is covered not simply with bones, but with certain softer membranes, which act as a further protection, so that it is very thoroughly guarded from injury.

If we cut the cord directly across, it will appear as we see it in Figure 67. Like the brain, it is divided by deep furrows into two parts, the right half and the left half. The furrows, as the figure shows, do not extend all the way across the cord, but the two halves are united at their centre. At the very centre of the cord, Figure 67 shows a rather irregular mass, shaped somewhat like the letter H, with four arms running off to the sides. This material is of a dull gray color, and is called the **gray matter**. It contains nerve cells, which start and receive nervous impulses, or "messages." Outside the gray matter is a substance, whiter and more glistening, called the **white matter** of the cord. This consists of nerve fibres whose duty it is to carry up and down the cord the nervous impulses which are started and received by the gray matter.

FIG. 67. — TWO PIECES OF THE SPINAL CORD.

Showing the gray matter and the two roots of the spinal nerves. The arrows show the direction of the stimuli.

THE NERVES

The brain may be regarded as the superintendent of the body. If this superintendent is to have any control over the different organs in the body, it must in some way be connected with them. The superintendent of a factory often has telephone connection with every room in the building by means of electric wires which run in various directions. In a similar way the superintendent of our body, the brain, is connected with every part of the body by a series of connecting fibres, which we call **nerves**.

Figure 66 shows these nerves coming from the spinal cord as it passes down through the back. The nerves start in the gray matter of the cord, and then pass from the cord between the vertebræ, extending outward into the body to connect with all the organs controlled by the brain. As may be seen from Figure 67, each of these nerves rises from the cord in *two branches*, known as **roots**. The front branch, called the **anterior root**, carries nervous impulses from the brain to the muscles; while the other, the **posterior root**, carries nervous impulses from the skin and other organs to the spinal cord and thence to the brain.

After the two branches unite, as shown in the figure, they form what we call a **nerve trunk**. Such a trunk is made up of thousands of nerve **fibres**, or wires, bound together in a bundle. Each fibre runs to a distinct part of the body. Figure 68 shows a bundle of fibres that make up a nerve. A nerve trunk usually con-

tains some fibres that carry impulses toward the brain and some that carry them away from it. A few nerves, however, contain only one kind of fibre. By means of these hundreds of thousands of nerve fibres every muscle, every gland, every part of the skin, receives and sends nervous impulses to and from the brain.

FIG. 68. — A NERVE.
Showing on the right a nerve composed of the many nerve fibres and on the left a single nerve fibre.

The wire that rings an electric bell is always connected with two different pieces of apparatus, without which it would be useless. At one end of the wire is placed the bell to be rung; at the other end there is a battery, which starts the electric current that rings the bell. The wire serves simply to connect the battery with the bell. The nerves in our body serve, in a similar way, to connect two pieces of apparatus placed at their ends, corresponding to the battery and the bell.

If we could examine carefully the nerve **fibres**, we should find that many of them end in a minute, somewhat rounded body, with numerous branches extending from it on all sides (Fig. 69). This body is called a **nerve cell**, and it corresponds in its work to the battery that starts the electric impulse to ring the bell. Since

the nerve cells are the organs that start and receive nervous impulses, we should expect to find them most numerous where stimuli are sent out to the various organs; and this is the case. There are a great many nerve cells in the spinal cord, and in the brain they are so numerous that we cannot even conceive of their number. It is estimated that the brain contains 9,000,000,000 such cells.

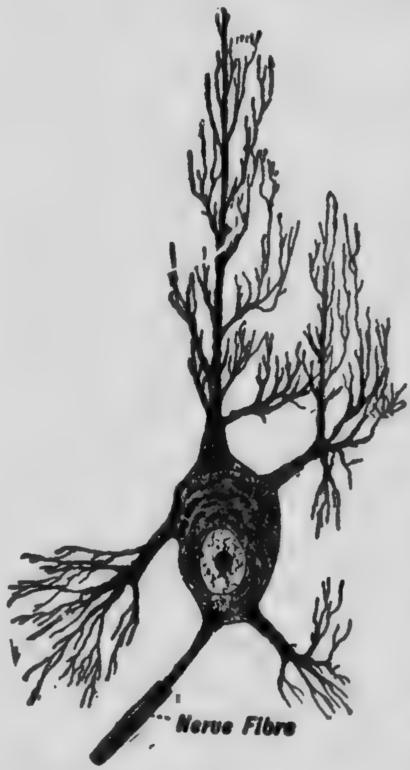


Fig. 69. — A Nerve Cell. Showing branches and a single nerve fibre arising from it.

We may think of one of these cells as a tiny battery which can start nervous impulses over the nerve fibres leading from it, or as a bit of apparatus which receives impulses coming over other nerves. Each nerve cell is connected by a long nerve fibre with some part of the body. There is no part of the body, no matter how small, that is not connected with the nerve cells of the brain and spinal cord.

The nerve cells in the brain are, most of them, near the surface. The rest of the brain consists of a complex tangle of fibres running in all directions, somewhat like the series of wires that run into a central telephone station; only instead of a few hundred such wires the brain has hundreds of thousands.

QUESTIONS

1. What is the relation of the nervous system to the rest of the body?

2. What is the brain?

3. What are the parts of the brain?

4. Where is the medulla? What is its work?

5. If the cord is cut across below the medulla, why would breathing stop at once?

6. What is the cerebellum? What actions does it control?

7. How is the cerebrum arranged? What powers does it control?

8. What is the spinal cord? Where is it situated?

9. What does a cross section of the spinal cord show of its structure?

10. What is the purpose of the nerves?

11. If the posterior root of a nerve (see Fig. 67) were cut, could the person receive sensations through that nerve? Why?

12. How do the brain and spinal cord resemble an electric battery?

13. Why are there more nerve cells in the brain than elsewhere?

CHAPTER XI

THE NERVOUS SYSTEM IN ACTION

DUTIES OF THE NERVES

IF we touch the hand with a hot match, instantly we have a feeling of pain and the hand is drawn away. The hand is connected with the brain by the nerve shown in Figure 70. If this nerve of the arm should be cut at the point indicated in the figure, and then the match should be touched to the hand, no pain would be felt. What is more, if we should wish to move the hand, we should be quite unable to do so. Cutting the nerve, therefore, destroys all sensation and all power of motion in the hand. The cutting does not injure the muscles directly. They would still be able to contract, if they were stimulated by an electric shock. Moreover, cutting does not destroy sensation; for if the end of the nerve which is still attached to the brain (called the central end in Fig. 70) were pinched, we should feel pain. And what seems most strange of all, we should think that we felt the pain in the hand and fingers, although the nerve had really been touched at a point above the elbow. These facts teach us several things in regard to the action of the nerves.

1. The nerves form a line of communication between the brain and spinal cord and the muscles. By the nerves the brain causes the muscles to act.

2. Muscles commonly act only when they receive a nervous impulse from the brain and spinal cord.

3. Nerves form a means of communication between the different parts of the body and the brain, by which messages (sensations of pain, for example) are sent to the brain.

4. Sensations are really felt in the brain, although we seem to feel them in other parts of the body.

The burning match touched to the skin of the hand causes a message to travel up the nerve, but no feeling of pain results unless the message reaches the brain. When, therefore, the nerve is cut or compressed so that the message cannot get to the brain, no sensation of pain is felt. If the message does reach the brain, however, it produces pain, and we locate this pain in the hand where the match touched it. The brain always locates the pain at the end of the nerve which brings the message, and for this reason it sometimes makes a mistake.

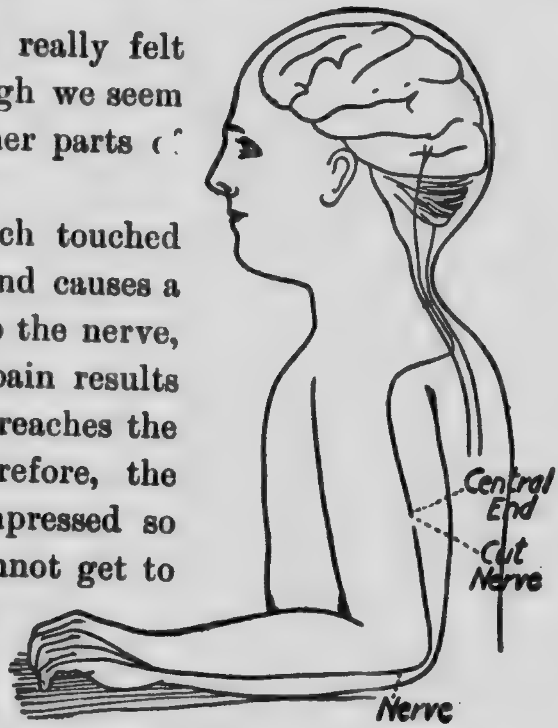


FIG. 70.
Showing the connection of the hand with the brain by a nerve. It is supposed to be cut above the elbow.

For example, the nerve from the hand has all our

lives brought messages to the brain from the hand. Now if this nerve is cut above the elbow, as in Figure 70, it can no longer bring messages from the hand. But if the central end, also shown in the figure, is pinched, the nerve carries the impulse to the brain. Since the brain has always received over this nerve impulses coming from the hand, it is now not able to recognize that this impulse does not come from the same place. So the sensation seems to come from the hand, when in reality it started from above the elbow.

These facts make it clear that the nerves are merely conducting wires carrying impulses that start at their ends. Some impulses start at the outer ends and go to the brain, producing sensation there. Other impulses start in the brain and pass down the spinal cord and out to the muscle fibres, where they cause motion of the muscles. Messages travel thus through the nerves in both directions, and by means of them the brain is placed in communication with every part of the body.

The nerve fibres by means of which sensation is communicated *to* the brain are called **sensory nerve fibres**. Those which convey the impulses *from* the brain to the muscles are called **motor nerve fibres**.

DUTIES OF THE SPINAL CORD AND MEDULLA

The spinal cord has more complicated duties to perform than have the nerves. Carrying messages to and from the brain is simply one of these manifold duties. As can be seen from Figure 66, large numbers of nerves

enter the spinal cord, and in the cord itself they pass up to the brain. These nerves are all so arranged that messages passing through them from the right side of the brain reach the left side of the body, and messages starting from the right side of the body reach the left side of the brain.

Independent Action of the Cord. — We have learned that the spinal cord contains nerve cells as well as nerve fibres. If these nerve cells serve the same purpose as batteries, we should naturally expect that the spinal cord could do something besides simply carry messages. The cord does indeed have another kind of duty, called **reflex action.** If, for example, a finger is pinched, an impulse is started which passes to the spinal cord on its way to the brain. In the spinal cord it excites certain cells. These in turn excite other cells, from which instantly motor impulses are sent out from the spinal cord to the muscles controlling the arm and hand, causing contraction and the withdrawal of the finger. This is called reflex action, and it takes place very quickly — in less than one tenth of a second. The original sensory impulse, of course, may pass on to the brain, causing the feeling of pain, but the instantaneous withdrawal of the finger from danger was a reflex action, entirely independent of the brain action. Reflex action does not require any will power and can take place just as well when a person or an animal is asleep as when he is awake. In the case of some animals it will take place when the brain has been entirely removed from the body.

A reflex action never starts itself. It must always be started by some outside stimulus. To produce such a reflex action something must stimulate the body in such a way as to cause a message to go to the spinal cord. The action never begins in the spinal cord itself, but always at the outer ends of the nerves, usually because something touches the skin or some other part of the body.

Although the brain is not necessary to reflex action, still it is possible for the brain partly to control such action, especially if the action is a repeated one, or one of which we are aware in advance. For example, if the bottom of the foot is tickled, the foot is pulled away. This is a reflex action and will take place when we are asleep just as readily as when we are awake. If, however, we are awake and know what is to be done, we can often use sufficient will power to prevent the foot from being pulled away even when it is tickled. The will power is exerted through the brain alone and, therefore, in this case the brain stops the reflex action. But under some circumstances, even when we are awake, our will power is not strong enough to prevent the reflex action. If a bit of food becomes caught in the windpipe, for instance, it will cause us to cough, and no matter how hard we try, we shall be unable to keep from coughing until the food is dislodged. The coughing is a reflex action and, in this case, is too strong to be controlled by will power.

Reflex Action in the Medulla. — A study of the medulla, indicated in Figure 65 as at the top of the spinal

cord, shows that this part of the brain controls a number of the most important vital functions. Here are centred the powers that control *breathing*, the *rapidity of the heart beat*, *swallowing*, the *size of the blood vessels* (thus regulating circulation), and some others of less importance. These actions are all reflex. It will be recognized that these actions are the primary functions of life. If they continue, the person will live, even though all others cease for a time. The activity of the cerebellum and cerebrum may stop for a while and yet the person may continue to live if the medulla is not injured; but if the medulla is injured, it may stop the heart beat and breathing at once, and thus produce instantaneous death, even though the rest of the brain is uninjured. The medulla may thus be said to be the centre of the vital functions. The centres controlling these vital functions may act quite independently of will power or consciousness, as they do when we are asleep.

THE CEREBELLUM AND CEREBRUM

The Work of the Cerebellum.—The cerebellum controls reflex actions more complicated than those connected with the spinal cord. Such actions as walking are at first controlled by our will power and are not reflex at all. After a time, however, they become reflex in a measure, and take care of themselves. When we first begin learning to play the piano we must think carefully of the action of each finger, but after playing for a number of years, we no longer need to attend par-

ticularly to the fingers. We simply place our hands on the piano and the fingers fall naturally upon the proper keys and make the proper motions for producing music. A skilled pianist can talk to a friend and at the same time continue playing, paying no attention to his fingers and yet never striking wrong notes. Through long practice certain parts of his brain, probably in the cerebellum, have learned to take care of the motions of the fingers, so that the mind is free to attend to something else. Some of these complex actions are controlled by the cerebellum, but physiologists as yet know little about them or where they are located.

The Work of the Cerebrum. — The upper and larger part of the brain, the cerebrum, is the real centre from which all the impulses of our conscious activity come. It is the centre that regulates the conscious action of the whole body.

The relation of the cerebrum to the other parts of the body may be best understood by the comparison already used, of the superintendent and the factory. The cerebrum itself is like the general superintendent who directs the work of the whole factory. The various centres in the cerebellum and the spinal cord are like the foremen of different rooms or of different parts of the work. When the superintendent wishes something to be done, he sends a message to the foreman of a special room, and the foreman gives the order to the individual workmen. In this way the superintendent is not obliged to pay attention to the detailed work of

every employee, but can give his time to planning the operations of the factory as a whole.

So the mind, when it wishes some special action to be performed, such as moving the hand, sends a message to some of the centres in the lower parts of the brain, and these forward the necessary commands by way of the nerves to the muscles in the arm and hand, so that the hand is moved. After the various centres have learned their duty, the mind itself does not need to attend to the little details. Our minds are then free for thought. We can talk as we play on the piano because the mind has trained some of its servants in the cerebellum to look after the contractions which cause the fingers to touch the keys correctly. If these servants in the cerebellum are not carefully trained, the plans made by the mind will not be properly carried out. Our education, from the time of our earliest childhood, is largely given to training the servants of the mind. We sometimes call the training of these servants *acquiring habits.*

THE IMPORTANCE OF HABITS

We can readily see how necessary it is that we should have well-trained servants to do our work, and, therefore, that we should form good habits. After we have once formed a habit it is very difficult to get rid of it. The training of children at home and at school is for the purpose of developing right habits of thinking and acting, in order that, after they become men and

women, they may be properly guided by these good habits.

By doing the same thing again and again the body becomes so accustomed to a certain kind of action that

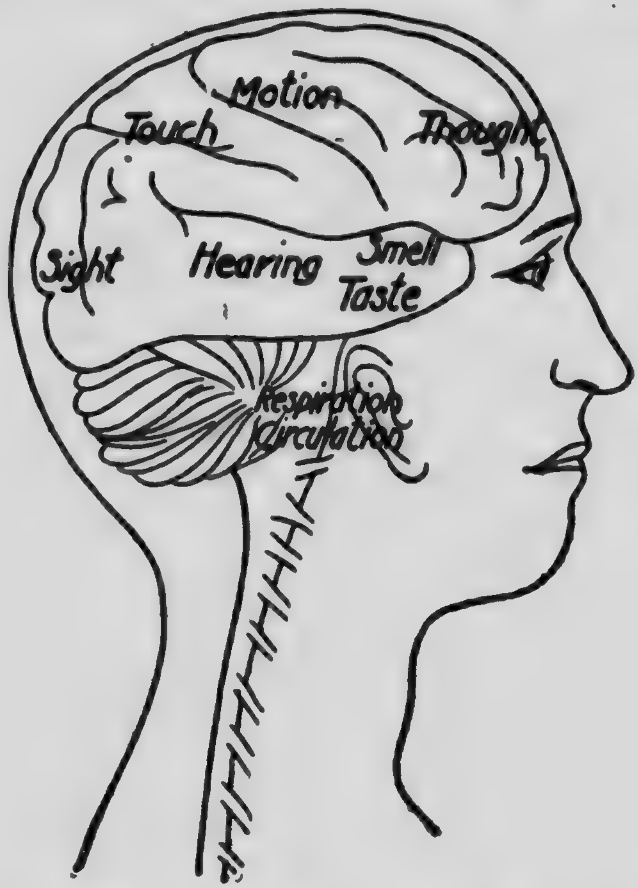


Fig. 71. — The Brain in Position.
Showing the location of the different powers in the brain.

it will be "second nature" to perform that action. Every time that we do something in a certain way it becomes easier to do the same thing in that way ag. . If the habit is an injurious one, like the alcohol habit,

we come more and more under its influence by yielding to it. If, on the other hand, the habit is a useful one, we fit ourselves better for life every time we perform the action. This is as true of moral actions as it is of muscular movements. If we exaggerate the facts when we tell a story, we are forming a habit that will grow until we become liars, unless the fault is overcome. If we dawdle over our books instead of giving our best thought to study, we are forming habits of inattention that are likely to hinder successful work through life. We are constantly forming habits whether we wish to do so or not. Inasmuch as these habits are to be our servants through life, it is wise to see to it that we form those that will be useful rather than those that may do us harm.

We know very little in regard to the location of the different powers of the cerebrum. Figure 71 indicates about all that is really understood. The power of *thinking* is probably connected with the front of the brain, certain powers of *motion* with the middle, while some of the *senses* are located in the back part of the brain.

THE CARE OF THE MIND

Our entire lives are directed by the mind. We should, then, take the best possible care of these minds of ours. A few facts of importance are worth remembering.

Sleep. — We cannot continue one form of activity very long without some kind of rest, for both the body and the mind need to rest. The most complete kind

of rest for mind and body is sleep. When we sleep, the mind is largely free from its usual forms of activity, although our dreams show us that the mind is not entirely inactive. The deeper the sleep the less distinct will be the dreams. The amount of sleep needed by various people differs greatly. A young child needs twelve hours out of the twenty-four for sleep, a growing boy or girl about ten, while most grown people require only about seven or eight. Some persons seem to get on very comfortably with even less. It is best to remember, however, that we are much more likely to have too little sleep than too much.

Sometimes a boy or girl takes a kind of pride in sitting up late and studying far into the night. This is likely to be done just before examination time, under the impression that better preparation can thus be made for the tests. This is a great mistake. Sitting up late to study, the night before, usually renders one less fitted to pass an examination. The many facts we try to cram into our heads during such midnight study are not all found there the next morning. We are weary, and the brain does not work as it should. To get a good night's rest is a much better method of preparing for an examination than to study until the mind gets tired.

Concentration. — The person who accomplishes the most is the one who is able to turn his whole attention to his work. When we are thinking of several things at once, we can give none of them careful consideration. If, when we are supposed to be studying, we let

our thoughts wander to the athletic field, then to the woods and the trout brook, then to something going on in the schoolroom, bringing them back finally with an effort to the lesson, it will take us much longer to master the le on than it will if we give our attention to that and nothing else. The pupil who applies his mind wholly to the lesson he is preparing will do his work much more quickly and much better than his neighbor across the aisle who studies one minute and dreams the next. The ability to think of one thing at a time is largely a habit, and one of the most useful of habits. It is one that can and should be acquired by every boy and girl. If we allow our thoughts to wander from one thing to another, we shall let this habit master us, and in later life we may, as a result, find it very difficult to think continuously and vigorously.

Recreation. — The mind needs recreation as well as work and rest. It ought to be employed at times in such a way as to obtain relief from its required tasks. We ought just as much to give our minds recreation as to give them sleep. Without it we become dull, and our bodily health is likely to suffer. Recreation is even more necessary for the boy or girl who wishes to be a scholar than it is for the person who works principally with his muscles.

Each of us should choose his own recreation. It should be something that gives pleasure and enjoyment, and it must be something that we do from *choice*, not because we *must*. It is also necessary that the kind of recreation a person takes should occasionally be

changed. Much of a person's success as well as happiness in life depends upon his having enjoyment. We can work harder and do better, if we may look forward to pleasant recreation as the reward for faithful labor.

Dependence of the Mind upon the Body. — Our minds and our bodies are related so closely that their welfare cannot be separated. If we allow our bodies to become weak from lack of exercise or want of the proper kinds of food, our minds will not be vigorous. The most active mind, and the one that thinks best, will be found in a healthy body. The boy or girl who enjoys books and study is the one who must be especially careful to give proper attention to health. The student must have recreation, exercise, good, wholesome food, fresh air and sunshine, if he wishes to preserve at its best that valuable treasure, his mind. The boy or girl who neglects mind for body cannot compete in after life with the person who studies hard. On the other hand, the boy or girl who neglects bodily health for the sake of knowledge is sure to fall behind the one who develops a healthy mind in a healthy body.

The Mind and Narcotics. — One matter of importance in connection with the proper care of the mind is keeping it free from the control of all narcotics. The use of alcohol has its first and most important effect upon the action of the brain. The first result of taking alcohol seems to be to excite the brain, and for this reason it is called a stimulant. But its chief action upon the brain is really the opposite of a stimulant, for almost at once it begins to *dull the mental powers*. This dulling action

becomes very noticeable if more than a small amount of alcohol is used.

Careful testing has shown that one who has taken even small quantities of alcohol cannot add a column of figures so quickly as usual, or that if he can add the column as quickly he may fail to do it accurately. He may be able to talk more rapidly, but he will commonly not think so clearly. He acts more slowly than usual. If he is hunting, he loses his straight aim; if setting type, he works less rapidly and makes more mistakes. He is perhaps not conscious of all this, and feeling somewhat excited and exhilarated, he may actually think that he is doing more work than usual, while he is really doing less. He may believe himself to be bright and witty, when he is uttering only foolish jests. The man with whom he has business dealings, and who keeps sober, gets the better of him in a bargain. If he uses more than a comparatively small amount of alcohol, the dulling effect becomes so great that he presently notices it himself. He finds that he is unable to talk intelligently; he becomes confused and stupid, and finally is unable even to walk straight. When he is completely under the influence of alcohol, nearly all the actions of his body cease, except breathing and the beating of the heart.

There are various degrees in this dulling effect of alcohol. It is slight when small amounts are used, and complete when large quantities are taken. How large an amount a person can take without having his judgment seriously affected it is impossible to say. But

even the very small amounts appear to have some dulling action upon the mind. Some of the keenest thinkers have found that their power of concentrated thought is dulled by taking even very small amounts of alcohol.

QUESTIONS

1. How do we know that sensations are felt only in the brain?
2. If the spinal cord were cut across at the shoulders, what effect would it have on the lower parts of the body?
3. What have the nerves to do with sensation?
4. What is reflex action?
5. Where is reflex action controlled?
6. If a person's foot is tickled, what action and reflex action occur? Do you suppose the foot would be pulled away if the person were asleep?
7. What reflex actions are controlled by the medulla?
8. What kind of reflex actions are controlled by the cerebellum?
9. Why should you think coughing to be a reflex action?
10. What are the duties of the cerebrum?
11. Why is it important that good habits be formed?
12. In what ways can the mind be cared for?
13. Why is sleep necessary?
14. If a person goes to sleep while sitting up, he is likely to fall over. Why is this? Would he be as liable to fall over as he would be if he fainted?
15. Why should we learn the habit of concentration? How may it be learned?
16. What is recreation? Why is it necessary?
17. What is the effect of alcohol upon the mind?

CHAPTER XII

THE SENSES

THE brain is shut up tight in its bony box, the skull. It has no direct contact with the external world, and yet it succeeds in finding out very well what is going on outside of our bodies, just as a telegraph operator, shut up in his little office, can learn what is going on in the world. As we have learned, the brain is connected with the outer parts of the body by the sensory nerves, which bring messages, or impulses, from the exterior. They extend from every part of the body to the spinal cord and the brain, and bring messages from every part. The messages, when they reach the brain, produce what are called **sensations**, and it is through the sensations that we get our knowledge of the outer world.

There are several outside forces that may excite the sensory nerves to send impulses to the brain. One of the most common of these is a touch upon the skin, which sends an impulse that gives rise in the brain to a sensation which we call **touch**. Similar sensations can come from every part of the skin. There are also several forces capable of starting impulses through special nerves. *Light*, for example, starts impulses from the eye through its nerve, *sound* from the ear. Through

these special nerves we get our sense of **sight** and of **hearing.** Some substances excite impulses from the tongue, giving a sense of **taste**, and others from the nose, giving the sense of **smell.** These act by means of special organs, situated at the ends of particular nerves, which we call **sense organs**. These four senses are known as the **special senses.**

THE SENSE OF SIGHT

The Eyeball. — The eye itself is shaped like a ball, as shown in Figure 73, although as we look at it in a person's face it appears quite unlike a sphere. This is because we see only a small portion of the front of the eye, the rest being hidden behind the eyelids. The only part of the eyeball that we can see is just what appears between the eyelids, and the eye will look large or small according to whether the eyelids are wide open or partly closed. Different people appear to have eyes of various sizes, but the dimensions are really always about the same; that is, the diameter is close to one inch.

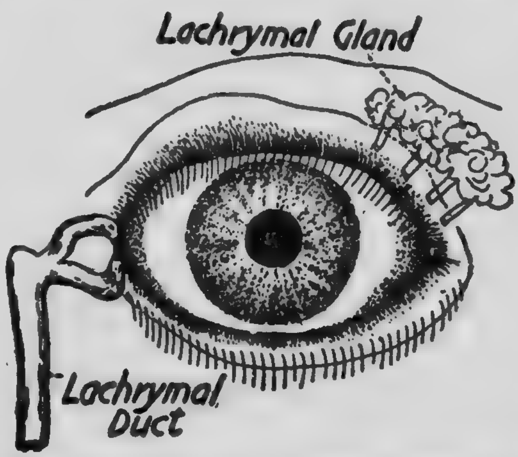


FIG. 72. — THE EYE, VIEWED FROM IN FRONT.
Showing the tear gland and tear duct.

The eyeballs are set in deep sockets in the front of the skull, as may be seen from Figure 73, only the

front surfaces being exposed. The sockets protect the balls from injuries which might come from blows.

The Eyelids. — Two folds of skin hang over the eye, one above and the other below, as may be seen in Figure 73. These are **eyelids**, which open and close over the eye. When closed, they serve to protect the eye and also to keep its surface clean and moist. Even when we are awake the eyelids close every few seconds. We are quite unconscious of this movement of the eyelids, but we can easily observe it by watching the eyes of some one near us. The front of the eye is extremely delicate, and if the lids did not constantly cleanse its surface, and if the tear secretions did not wash the dust away, the eye would become inflamed, and the sight be affected. The eyelids, by means of their long lashes and their exceedingly quick motion, serve also to guard the eye against accident. The hairs on the edges of the lids, called the **eyelashes**, assist in keeping out the dust.

The Tear Gland. — The lids are aided in keeping the eyes clear by the tears. A small lachrymal gland, or **tear gland**, is lodged just above each eye, on the side away from the nose. This gland produces a watery liquid, which flows down over the eye and keeps its surface moist. The liquid flows over the eyeball to the inner edge of the eye near the nose, where there is a tube, the **tear duct**, leading to the cavity inside the nose, as shown in Figure 72. The tears, after washing the surface of the eye, pass through the duct into the nose and the throat, and are then swallowed. Usually the gland produces just liquid enough to wash the

eyeballs and to pass easily down the lachrymal duct. But when a person cries, the tears are produced so

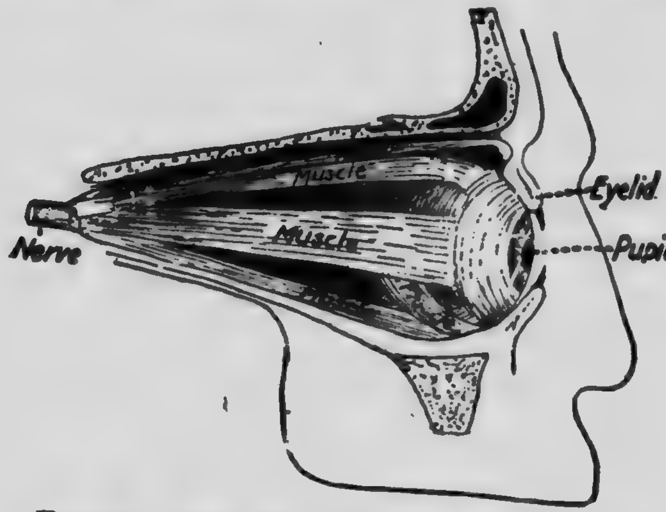


FIG. 73. — THE EYE, VIEWED FROM THE SIDE.

Showing its shape, the socket, and the attachment of muscles.

rapidly that they cannot all pass through the duct into the nose. They then overflow and run down the cheeks.

The Eye Muscles. — Six small muscles are attached to each eyeball to move it. One is on the top, one on the bottom, one on each side, and two others have an oblique position. Figure 73 shows the form and position of these muscles. By the contraction of the muscles the eyeball can be turned in any desired direction.

Structure of the Eyeball. — If we examine a photographer's camera, we find that it has three chief parts. There is (1) a *dark chamber*, the box of the camera, closed so as to admit light only from the front. In the opening in front which admits the light there is (2) a *lens*, which makes an image of the object to be photo-

graphed; at the back of the camera is (3) the *sensitive plate*, upon which the picture is taken.

The human eye is made upon much the same plan as the camera, although differing in details. Like the camera, it has a dark chamber and a lens, and also a sensitive surface at the back. If we examine Figure 74, we can see how closely the eye and the camera may be compared. The eyeball is a *dark chamber*, which, like the camera, admits light only from the front. At the point where the light is admitted there is a *lens*, shown in Figure 74, and at the back of the eyeball is a sensitive surface called the **retina**, shown in Figure 75. Between the front of the eye and the retina the eyeball is filled with transparent liquids, through which the light can easily pass.

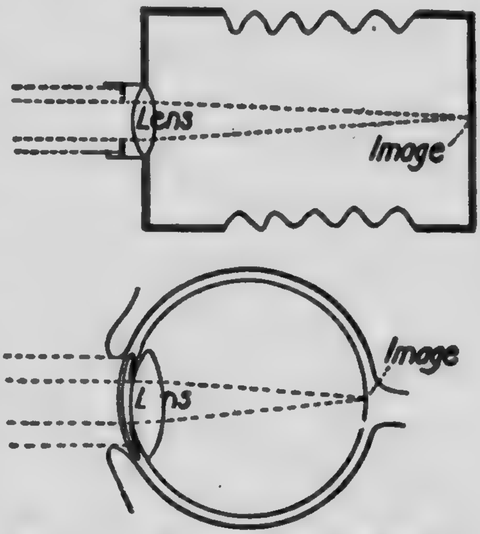


Fig. 74. — A Comparison of the Structure of the Camera and the Eye.

Light enters the eye from the front, passing through the small opening known as the **pupil** (Fig. 75). Just inside of this pupil is a transparent lens. The lens is so shaped that the rays of light are changed in their direction and come together at the back part of the eye. When they come together they produce a little picture or image of the objects from which the

light comes. This image is similar to what we see on the ground-glass screen at the back of a photographer's

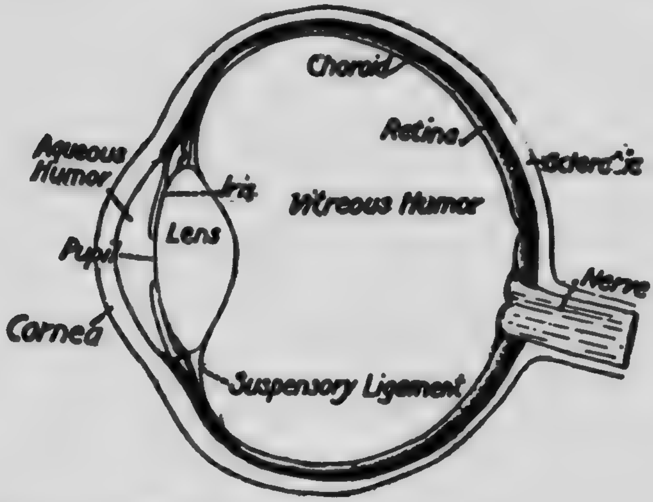


FIG. 75. — A DIAGRAM REPRESENTING A SECTION THROUGH THE HUMAN EYE.

camera, which shows a picture of the objects toward which the camera is pointed. In the same way a little picture is formed upon the back part of the eye. The part of the eye upon which the image is formed is the retina, and is the sensitive part.

The retina is full of nerves, and in some wonderful way, not fully understood, these nerves send impulses to the brain, by which the brain receives and recognizes the picture. If the nerves that connect the eye with the brain were cut, the message could never reach the brain, even though the image should be formed on the retina. If the eye were injured so that the image could not be formed on the retina, we could not see, even though the nerve were in good condition.

The lens that forms the picture on the retina is not able to form a picture of both a near and a distant object at the same time; hence we cannot see clearly near objects and distant objects at the same moment. If we are observing a hill some distance off, and wish to look at a pencil in our hands, the shape of the lens changes a little so that the pencil becomes sharply pictured on the retina, but, at the same time, the hill necessarily becomes blurred to our sight.

Nearsightedness. — If the eyeball is of exactly the right shape, ordinary objects will be sharply pictured upon the retina. If, however, the ball is a little too long, distant objects will not be clear, not sharply focused as we say, but they will look blurred. A person with such eyes cannot see distant objects clearly, though he can readily see objects quite close to the eyes. We say he is *nearsighted*, and, in order to see clearly, he is obliged to wear glasses especially prepared to overcome his difficulty.

Nearsightedness is very common. It is often due to improper habits of study. We are likely to lean over a desk or a table when we read, thus bringing the book very close to the eyes. This habit, if continued, is certain to cause such changes that the eyes, which at first could see clearly, become little by little so affected that only near objects can be clearly seen. Such nearsightedness is quite common among people who spend their early years in study. The difficulty is less common among those who live out of doors and who do little or no reading. If we will take pains to sit erect

when reading or studying, and to hold our books no nearer than a foot or eighteen inches from the eyes, we shall greatly reduce the tendency to nearsightedness. If we lean over our work, holding a book within six inches of the eyes, we shall be quite sure to develop nearsightedness.

Color Blindness. — Some people have the sense of color poorly developed, and we call them *color blind*. This does not mean that they cannot see any color at all, but that they confuse the various colors. The most common form of color blindness is the inability to distinguish clearly reds from greens. Since red and green are the colors used as signals on railroads and steamboats, a pilot or a railroad engineer who cannot distinguish them readily may commit such blunders that accidents will result. Persons who are to hold responsible positions on railroads or steamboats are accordingly required to have their eyes specially tested for color, and no one who is color blind should ever think of taking such a position. The difficulty is more common among men than among women, and no remedy for it is known.

Care of the Eyes. — 1. The eyes were made to be used, and it does them no harm to exercise them constantly. If, however, they are used on work that requires close attention, such as reading or sewing, they become tired and should frequently be allowed a moment for rest, such as is gained by closing the eyelids or by looking at distant objects.

2. We should not abuse the eyes by reading in a

dim or flickering light. Nor should a bright light, like the sun's rays, be allowed to fall upon the page we are reading. We should never look directly at a bright light.

3. The only proper position for holding the head when we read is erect. Reading, when lying on the back or in a hammock, is very injurious to the eyes. We must not forget, moreover, that using the eyes means also working the brain. When the brain is tired, one is often inclined to lie down and read a book — setting the tired brain to work again, and under conditions bad for the eyes themselves.

4. If a child has difficulty in seeing objects clearly, his eyes should be examined by an oculist. Headaches are frequently due to trouble with the eyes, and if a child has a tendency to headache, his eyes should be examined. It frequently happens that the trouble with the head may be cured by the use of glasses prescribed by a competent oculist.

5. Particles of dust that get into the eyes are usually carried off with the tears by way of the tear duct, and a few winks remove them. If this is not sufficient, the trouble may frequently be remedied by lifting the upper eyelid with the fingers and drawing it down over the lower eyelid. If this does not remove the particle of dust, it may be taken out by some competent person who can pass gently over the eyeball the end of a soft handkerchief rolled up to a point. If this attempt fails, a physician should be called. The eyes, in such cases, should *never be rubbed*. The eyes are

organs too delicate and too important to be treated by incompetent persons. If one has trouble of any kind with his eyes, he should consult a physician or an oculist.

THE SENSE OF HEARING

The Ears. — The two projections on the sides of the head, which we commonly call the ears, have very lit-

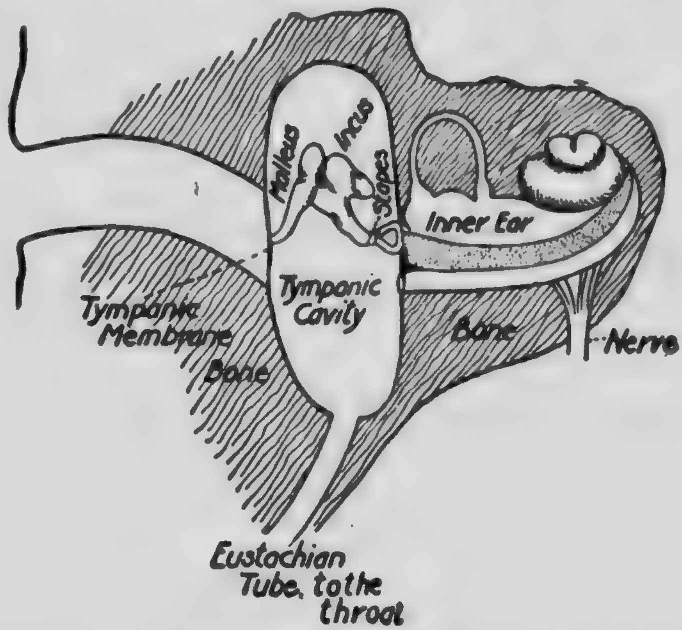


FIG. 76. — THE EAR.

A section through the "stony bone," showing the parts of the ear.

tle to do with hearing. They are only bits of cartilage covered with skin, which serve, perhaps, to collect waves of air, and probably make sounds a little louder. The real hearing organ is the **inner**, or **true ear**, which is wholly inside the head and embedded in the bones. The ear itself is in the middle of the hardest bone in the body, called the **stony bone**. The

ear is thus more thoroughly protected from external injury than any other organ.

The ear is a very complicated organ. Its general structure may be seen from Figure 76, which shows a section through the side of the head, giving the chief parts of the ear. The passage from the outside to the true ear, as the figure shows, is slightly bent. In it there is secreted a little wax, which helps keep it moist and flexible. The passage is closed at the inner edge by a membrane which is stretched across. This is the **tympanic membrane** or **drum.** It is tough and elastic. Earache in children is usually caused by sores in the ear; these occasionally make little holes through the membrane, which interfere somewhat with hearing. Sometimes very loud noises, like explosions, break the drum and make the person deaf.

Figure 76 shows that beyond the membrane there is a cavity. It is known as the **ear drum,** or **tympanic cavity,** and is also sometimes called the **middle ear.** The ear drum is filled with air, which enters it through a tube in the lower side. This tube leads to the throat, as indicated in Figure 76, and is opened every time we swallow. In this way the drum is filled with air, and the pressure of the air in the drum is kept the same as the pressure of the air outside. If this tube becomes closed, as sometimes happens with inflammation of throat or nose, the air within the ear is partly absorbed, so that the pressure inside becomes less and the membrane is pushed in by the pressure of the outside air. This affects the hearing injuriously. This

is the reason why throat troubles are very apt to extend to the ears and interfere with hearing. Indeed, the most common cause of deafness is to be found in difficulties of the throat. Catarrh in the throat is one of the first things that a physician attends to in most cases of difficulty in hearing.

In Figure 76 it will be seen that three small bones (malleus, incus, and stapes) are stretched across the cavity of the middle ear. The outer of these ear bones is attached to the membrane and the inner one connects with the inner ear, which contains the real hearing organ. In this inner ear are many nerves. Sound is produced by waves of air which enter the ear and shake the tympanic membrane. This shakes the bones attached to it, and by their motion the effect of the air wave is transferred to the inner ear, where it reaches the nerves. This shaking or vibration upon the nerves starts nervous impulses which travel rapidly to the brain. When the messages reach the brain they produce a sensation which we call **hearing.**

Hearing. — Our ears tell us very little in regard to sounds except their loudness or softness, and their pitch (high or low). Our power of determining *distance* is limited. If we know what causes a certain sound, we can determine something of its distance by the loudness. We judge the distance simply by the loudness of the sound as compared with what we should hear if the sound were nearer or farther away. If, for example, we hear the whistle of a locomotive, and it sounds faint, we are sure that the engine must be a long

distance away, because we know that the sound itself is really very loud. If, on the other hand, we hear the buzz of a mosquito, and it sounds loud, we know that the insect is close to the ear. We can determine the distance of sound in no other way than by the comparative loudness.

Our power of determining the *direction* from which sound comes is not much greater. Noises coming to the ear from the side of the head may sound louder in one ear than they do in the other, and in that case we judge that the sound is on the side of the head where it seems loudest. Sometimes we unconsciously turn the head around a little, until we find that the sound appears to be loudest when the head is in a certain position. We then conclude that the noise comes from the direction toward which the ear is turned. But this test is by no means accurate.

Care of the Ears. — The ears require very little care. The use of solid objects, like pins or needles, to remove the ear wax is very unsafe. The ears may be kept sufficiently clear of wax by means of the little finger, which should be pushed downward as it is placed in the opening. Very loud sounds close to the head are likely to do harm. Boxing children's ears is liable to injure the membranes within. Pain in the ear may sometimes be relieved by placing hot cloths upon the ear; but if it persists, a physician should be called. It is well to remember that deafness is most commonly produced by throat troubles, and if one has any difficulty in hearing, he should first of all look to the condition of his throat.

Slight deafness is not unusual with children ; it renders a pupil apparently inattentive and dull. The child does not realize that he has any difficulty in hearing, and very likely neither his teacher nor his parents suspect it. Therefore a child who is inattentive should have his hearing tested. If deafness is the cause of the difficulty, a physician should be consulted at once to remedy the defect, if possible.

THE SENSE OF TASTE

By the sense of taste we learn something of the nature of liquids. Solid substances do not produce taste. It is true that many solid bodies have a certain taste, when taken into the mouth, but not until they are more or less dissolved in the saliva. If we rub the tongue dry, and then place upon it a lump of sugar, we notice no taste at first, but, as soon as the liquids of the mouth begin to dissolve the sugar, we perceive the sweet taste.

Location. — The sense of taste is located in the mouth, but not, as is commonly supposed, wholly in the tongue. The upper side of the tongue has a sense of taste, but the under side has not. Besides this, the roof of the mouth, especially at the back, has a sense of taste. When a substance is rolled around by the tongue at the back of the mouth, we find there the strongest sense of taste.

The Tongue. — The tongue of a healthy person is of a pinkish red color. If it is otherwise, the stomach is probably out of order. One of the simplest methods employed by physicians for detecting signs of certain diseases is an examination of the tongue. When this is

covered with a whitish or yellowish coating, or when it is bright red, the physician knows that something is wrong.

If we examine the tongue carefully, we find that it appears much as in Figure 77. It is covered with numerous little bunches or **papillæ**, which differ in appearance and vary in use. Some of them, particularly those at the back of the mouth, are associated with the sense of taste and are called **taste buds** (see Fig. 77). The tongue itself is made up principally of muscles, which run in many directions and enable us to move the tongue very easily. In addition to the muscles there are glands which secrete a watery material that keeps the tongue moist. There are also many blood vessels and nerves, among them some which are particularly connected with taste, and which carry to the brain the messages that enable us to determine the presence of sweet, sour, or bitter substances in the mouth.

Fig. 77. — The Tongue.
Showing the papillæ on its surface.

Tastes. — We think of the substances that we eat as having many different tastes. All kinds of tastes

may, however, be classified under four heads, — bitter, sweet, acid (sour), and salt. These different tastes are not perceived equally well in all parts of the mouth. We taste sweet things most delicately at the tip of the tongue, and bitter things at the back part of the mouth. We are very apt to confuse tastes and smells, and many sensations that we call tastes are really tastes and smells combined. When we drink a glass of soda water, for example, we have the sweet taste of the sirup, but the gases from the soda water pass into the nose and produce a very strong sense of smell. The two together are what we call the pleasant taste of the soda water. Many other so-called tastes are largely smells, as can be tested by blindfolding a person, holding his nose so that he cannot catch the odor, and then giving him successively small pieces of apple, onion, and potato.

Duration of the Sense of Taste. — Our sense of light is gone at almost the instant the light ceases to shine into the eye, and the sense of sound stops as soon as the vibration that produces it ceases or becomes too distant to affect the ear. The sense of taste, however, does not cease so quickly, but it may last many seconds, or even several minutes, after the substance tasted has been swallowed, partly because some of the substance remains in the mouth. An unusually bitter taste, like that of quinine, may last as long as half an hour.

The sense of taste easily becomes tired, and in this respect it is quite different from the sense of sight. We may use our eyes all day long, and yet see as clearly at

night as in the morning. But, if we continue to use our sense of taste for even a few minutes, it loses its acuteness. We can test this characteristic by eating a lemon. Food does not have so pleasant a taste at the close of a meal as at its beginning, so we often finish our dinner with a highly flavored dessert to please our taste, which has by this time become dull.

Our sense of taste is one of our greatest enjoyments, but to obtain the most pleasure from it we must not gratify it too much. If we live upon plain food, with an occasional luxury, we shall find more enjoyment in it than do people who are constantly eating highly flavored foods. The luxury gives special pleasure only when it is unusual. If we should eat the most delicious food constantly, it would soon come to give us less enjoyment. The bulk of our food should be such as satisfies the appetite rather than the taste. Finely flavored substances, like candies, sauces, and sweets in general, should be used in comparatively small quantities, if we wish to enjoy them as much as possible.

THE SENSE OF SMELL

The sense of smell enables us to determine the presence of certain gases. Only substances that are in the form of a gas or vapor can be smelled. Rose water is a liquid, but the only part that we smell is the vapor that rises from it. The amount of vapor required to excite the sense of smell is exceedingly minute. If a bottle of peppermint oil be opened for a few moments, it will give off a vapor that will fill the room and will be smelled

by every one present. Yet if the bottle of liquid be weighed in the most delicate scales, there will be no perceptible difference in the weight before and after the bottle was opened. No other sense is as delicate as that of smell.

Location. — The sense of smell is located in the cavities of the nose. The two nostrils lead into two large cavities above the mouth, separated from each other by a bony partition. The cavities extend backward to the throat. They are partly filled with large, thin, folded bones, which bend around so as to form curved surfaces. They give a large amount of exposure to the air, as it passes over them. Upon these bones are the nerves of smell (olfactory nerves), as shown in Figure 78. Vapors entering the nose, as we breathe, act upon these nerves in such a way that they send messages to the brain, and produce in the brain the sensation that we call odor or smell.

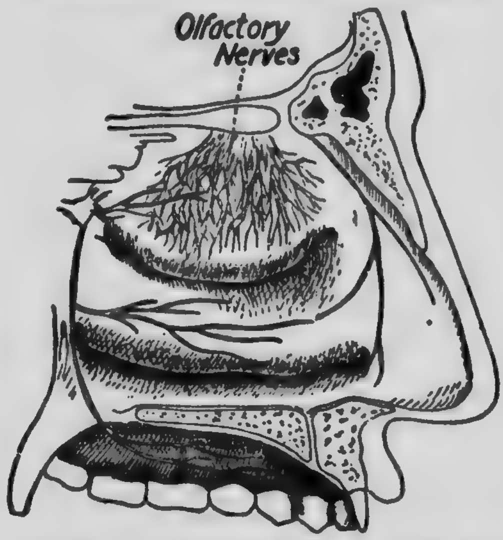


FIG. 78.—A VERTICAL SECTION OF THE NOSE.
Showing the nerves of smell.

Its Use. — The sense of smell in human beings is not so well developed as in some animals, or so useful. We may occasionally notice by its aid the presence of injurious gases, such as illuminating gas which is escaping

from a burner. Sometimes, also, we perceive through the sense of smell the presence of some body or substance which gives off a special odor, but which is concealed from our eyes. With other animals the sense of smell is much more keen than it is with human beings. A dog can follow his master's footsteps by means of his very keen sense of smell.

The acuteness of the sense of smell is blunted by continued use even more than is that of taste, as we can readily prove with cologne or other strong odor. The first whiff of cologne on a handkerchief gives a strong sensation. If, however, we bury our face in the handkerchief and continue to breathe the odor, we cease to smell the cologne. In order to perceive it again, we must remove the handkerchief from the nose and let the smelling organs rest for a time.

OTHER SENSATIONS

We frequently say we have five senses, — *seeing*, *hearing*, *tasting*, *smelling*, and *feeling*. The first four of these are quite distinct. The fifth, which we call **feeling**, is made up of several different kinds of sensations. There are really two different senses in the skin, — **touch** and **temperature**. In addition to these the term *feeling* usually covers the **pain sense**, **hunger**, **thirst**, and some other sensations.

The Touch or Pressure Sense. — The skin is sensitive to the **touch** or **pressure** of objects. Whenever a substance presses even very lightly upon the skin it excites the nerves in such a way that nervous impulses are

sent to the brain, which builds out of these impulses an impression, more or less distinct, of the object that touched us. We can easily test this by shutting our eyes and letting some one touch us with different kinds of unknown objects. The whole skin is thus an organ of touch, although it is more sensitive in some places than in others.

Through the messages that come to the brain from the skin we not only get a sensation that the skin is touched, and that the object touching it causes a certain amount of pressure, but we know quite accurately what part of the body is in contact with the object. We can tell whether the ring is on the finger or is lying on the palm of the hand, and whether it is on the little finger or the thumb. The delicacy with which we can determine where the skin is touched differs very much on different parts of the body, as can be easily discovered by experiment. It is most delicate at the tips of the fingers and the tip of the tongue. We can tell within a twenty-fifth of an inch where an object, like a needle point, touches the skin of the finger tips or the tongue. The sense of location is much less delicate on the back of the fingers, and still less so on various parts of the arms and shoulders. Upon the back of the shoulders it is least delicate of all; in fact, we cannot determine within two and a half inches where an object touches the back part of the shoulder. We can see from this that the parts of the body most used are the ones in which the sense of touch is the most delicate.

It is the sense of touch, or of location of touch

sensations, that gives us our most intimate knowledge of the nature of objects outside our bodies. By the sense of touch alone we can tell whether such objects are rough or smooth, whether they are blunt or sharp, whether they are solid or liquid.

The Temperature Sense. — When a warm body touches the skin, nervous impulses go to the brain, and we have a feeling of warmth. The skin, in general, is sensitive to both cold and heat, though some points on the skin are sensitive to heat and not to cold, while others are sensitive to cold and not to heat. The warm and cold spots are very close together, so that a body no larger than the head of a pin will in some places touch both. Every part of the body has a certain temperature, and if some object warmed to that exact temperature touches the skin, the pressure of the object will be felt, but it will seem to be neither warm nor cold. If, however, the object is a little warmer than is the skin at the point where it touches, it will seem warm; if it is a little cooler than the skin at that point, it will seem cold. The temperature of the skin is not just the same on all parts of the body. The temperature of the hand is usually a little lower than that of the forehead, so that an object which feels warm to the hand may feel cool to the forehead. The forehead itself feels warm to the hand.

If we step in cold weather from a carpet to a bare floor, the floor feels colder to the feet than the carpet, although the two are actually of the same temperature. The bare floor draws the heat away from the feet more

rapidly than the carpet does. Any object feels cool when it takes heat away from the body rapidly. If it withdraws no heat from the body, we feel that the object touches the skin, but we feel no sensation of cold resulting from the contact. Some substances draw heat more rapidly than others, and this is why, in cold weather, for example, metal objects seem colder than cloth to the touch.

Sense of Pain. — Almost any nerve which carries messages to the brain will carry a sense of **pain**, if it is strongly excited. If the pain is slight, we can determine very closely where it comes from; but if it is severe, we cannot locate it so accurately. A slight toothache, for example, can be located in the proper tooth, but when it is severe, it seems to come from the entire jaw, or the whole side of the head. Occasionally the whole upper part of the body appears to be in pain, although the trouble is confined to a single tooth.

We find it hard to realize that pain is of any use, but it really is of great value. If it did not hurt to burn the fingers, children would get their fingers so badly burned as to render them useless. In fact, they would probably destroy the fingers entirely before they were old enough to know how to take care of themselves. Pain thus warns us to guard our bodies from accidents and disease, and to keep them in as good a condition as possible. Pain is a *warning* to our bodies, and we should heed it as carefully as does the engineer the danger signal beside the railroad track.

The Muscle Sense. — We seldom hear any one speak of the **muscle sense**, but it is really of considerable importance. It is the sense by which we know when and how much we contract our muscles. Even when we shut our eyes we can move our fingers very accurately, knowing almost exactly how much the muscles contract. Let us say, for example, that we will allow one hand to rest upon the table while we close our eyes. If, while our eyes are still closed, another person lifts the hand, we can tell very accurately by means of the muscle sense how far it has been lifted. This sense is of great importance, for it enables us to control our actions and to move our muscles together. If we could not feel how much we move the muscles, we could not possibly make the body motions that require the contraction of a number of muscles at the same time, as when we throw a stone. The muscle sense is not situated in any particular place, but is present in all parts of the body, especially in the joints.

QUESTIONS

1. How does the brain get a knowledge of the world?
2. What are the chief sense organs?
3. What is the shape of the eyeball, and where is it located?
4. What are the eyelids? What is their purpose?
5. Where are the tear glands located? What is their use?
6. How are the eyeballs moved?
7. What are the principal parts of the eye?
8. Why is it desirable to sit erect when reading?
9. If the lens of the eye should become opaque, what would be the result?

10. Some persons cannot distinguish between green and ripe cherries. Can you explain the reason?

11. In what five ways should we care for the eyes?

12. Where are the real hearing organs?

13. What are the important parts of the ear?

14. How do the ears enable us to hear?

15. How should we care for the ears?

16. If two colors are mixed, do we get a new color? If two sounds are mixed, do we get a new sound or do we hear both sounds?

17. If you close the nose and swallow, what effect is produced in the ears? Can you explain why?

18. Where is the sense of taste located?

19. What is the structure of the tongue?

20. Mention several duties of the tongue?

21. What may be said of the duration of the sense of taste?

22. Where is the sense of smell located? How may this sense be dulled?

23. How could you tell whether soda water, without syrup, has a taste or only a smell?

24. What three sensations compose the sense of feeling?

25. What is the use of the touch or pressure sense?

26. What do we learn from the sense of heat and cold?

27. Lay the palm of the hand upon the cheek. Does the hand appear warm or cool? Do the same upon the forehead. What do you observe?

28. Of what use is pain?

29. Of what importance is the muscle sense?

CHAPTER XIII

HEALTH AND DISEASE

THE body is a very delicate piece of machinery, as we can readily appreciate. It needs to be treated carefully, but most of us have bodies that will keep in good condition if we care for them properly.

The Body cures Most of its Own Ills. — The human body is such a beautifully constructed machine that it will of itself take care of the ordinary slight illnesses. If we have a cold, the body soon cures it; wounds are rapidly healed; broken bones are mended; digestive troubles usually disappear. All of these little maladies the body itself can care for. We need simply to do our part toward keeping in good condition by eating plain, wholesome food, taking plenty of exercise, and living as much as possible out of doors in the fresh air and sunshine.

Many people have the idea that the proper way to treat ailments of all sorts is to take *medicines*. This is a great mistake. Medicines cannot cure disease. The most they can do is to aid the body to right itself. Most people would be better off by letting nature cure their little ailments, giving her the aid that comes from such simple remedies as baths, soaking the feet in hot water, and rubbing, rather than by dosing themselves

with drugs. Medicines should be used only under a physician's guidance. The constant use of drugs rather weakens than strengthens the general physical powers. If people used fewer drugs and more common sense, took less medicine and more exercise, wore fewer wraps in winter and spent more time out of doors, we should hear less about sickness, and the whole race would be more robust.

Disease. — When the machinery of the body is out of order we speak of the condition as sickness or disease. The causes of diseases are numerous. Sometimes they are the result of improper food habits, or intemperance, of breathing impure air, or of other improper conditions of life. One class of very important diseases is produced by parasitic animals or plants growing in the body.

Some diseases we say are "catching," by which we mean that one person very readily gets the disease from another. This class includes such diseases as measles, scarlet fever, mumps, whooping cough, etc. Such diseases are called *contagious*. Another class of troubles, like rheumatism, malaria, etc., are non-contagious, since healthy persons do not "catch" them from sick people.

PARASITIC DISEASES

Contagious diseases are probably all caused by very small animals or plants that get into the human body and multiply there. Most of them are so small that they can be seen only with the aid of a very powerful microscope.

Parasitic Animals. — There are a few **animal** parasites that occasionally get into our bodies and cause trouble. One of these is the *tapeworm*, which enters the body from raw or insufficiently cooked beef or pork. It lives in the intestines and makes considerable trouble, although it is not usually very dangerous. Another such parasitic animal is the *trichina*, which also comes from eating pork, not properly cooked, such as rare or slightly cooked ham or sausage. The disease resulting is violent and painful, and often causes death. The simple method of avoiding both tapeworm and trichina is to eat no meat that is not thoroughly cooked.

Another form of animal parasite produces *malaria*, or *chills and fever*. This parasite is a minute animal, to be seen only through a microscope, which gets into the body, usually from the bite of the mosquito. Certain kinds of mosquitoes are liable, when they bite, to leave in the skin some of these little parasites. The best way to protect ourselves against malaria or chills and fever is to keep from being bitten by mosquitoes of the Anophele variety which flourishes in certain localities. This may be done generally by covering the doors and windows of our houses with mosquito netting, particular care being taken to remain behind such netting at night.

Parasite Bacteria. — The most important of the parasites that make their way into the body are a type of plant called **bacteria**. These minute plants are so small that a powerful microscope is required to see them, and so light that they can easily float around in the air in the form of dust. They are very abundant everywhere.

Some of them, instead of being harmful, are directly useful to us. Bacteria cause the souring of milk and the decay of meat; they produce vinegar the flavor of butter and cheese, and they prepare the soil for the growth of plants. These tiny parasites are, on the whole, very useful friends of ours.

But while some bacteria are healthful, others, which may live as parasites in our bodies, produce certain diseases. Some of these are shown in Figure 79. *Typhoid fever*, *consumption* (tuberculosis), *diphtheria*, and *boils* and *abscesses* of the skin are produced by them. Other contagious diseases, like *measles*, *scarlet fever*, *mumps*, and *whooping cough*, are probably caused either by bacteria or by some other microscopic parasites. Each of the different diseases is produced by its own kind of bacteria.

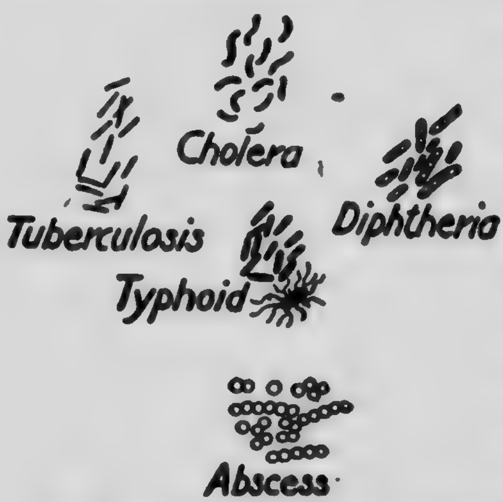


FIG. 79. — BACTERIA THAT PRODUCE CERTAIN DISEASES.

Protection against Harmful Bacteria. — Bacteria cannot ordinarily injure us unless they get inside the body. We have already seen how the skin forms a covering which protects the body from the entrance of external objects, and this commonly keeps out dangerous bacteria. So well are we protected that the majority of them do no harm whatever, because they do not obtain

entrance to the body. We need not be frightened, then, because bacteria are present in milk and water, for this is the natural condition. The bacteria in milk, and also those in water, are usually, though not always, harmless.

Even if the bacteria of diseases do find their way into the body, it does not necessarily follow that they will effect injury. The human body is able to fight these bacteria, and in many cases to destroy them before they do harm. When we are in the best condition of health, our power of resisting them is greatest, and consequently we are then less liable to take some contagious diseases than when we are in a more or less weakened state. In general, the best method of avoiding all bacterial diseases is to keep in robust health, although even perfect health apparently cannot protect one against taking some contagious diseases. Robust health, as we have seen, depends upon plain, wholesome food, plenty of fresh air and outdoor exercise, and living a regular life.

Immunity from Contagious Diseases. — Many contagious diseases, such as smallpox, scarlet fever, mumps, chicken pox and yellow fever, are rarely taken by the same person more than once. In some way, which we do not fully understand, the first attack acts upon the body so that it is able to resist the action of the parasites ever afterward. A person who has had one attack of such a disease is said to be *immune* to future attacks. Advantage is taken of this fact by vaccination, by which we are protected against smallpox. When vaccination

"takes," it causes what is really much like a mild form of smallpox, which makes us for a certain time *immune* to that disease.

Prevention of Contagious Disease. — The best way to check the spread of contagious diseases is to prevent the distribution of the bacteria that cause them. If we can keep these minute growths from passing from one person to another, we can frequently stay the spread of the disease. The rules adopted by the boards of health in our cities, especially in connection with schools, are made for the sake of preventing the spread of bacteria. That is why persons having contagious diseases, such as diphtheria, are placed in rooms by themselves. That is why children are not allowed to attend school when, for example, a member of the family has the measles. In general, the regulation of these matters may be left to boards of health, but there are a few facts which it is well for us all to understand.

How Bacteria get out of the Body. — When a contagious disease is "taken" from a person by another, the bacteria which produce the disease must have passed from the body of the patient to that of the other individual. Usually, the bacteria pass from the body of the sick person in some of the secretions or excretions. If the disease is accompanied by sores, such as boils, the bacteria leave the body in the discharges from the sores. If there is an eruption from the skin, as in scarlet fever and measles, the bacteria probably leave the body from the skin, as well as from the discharges of the mouth and nose. If there is a dis-

charge from the digestive canal, as in typhoid fever, bacteria find exit with what passes from the bowels. If the disease is in the mouth or throat, as in diphtheria, bacteria will usually be found in the saliva. If it is in the lungs, as in consumption, we may look for the bacteria in the saliva and phlegm coughed up by the patient. If the disease is accompanied by a cough, as in whooping cough, we may regard the breath during the coughing as carrying the bacteria.

How Bacteria are Carried. — 1. Many of the discharges from patients get into **sewage** through drains and closets. Hence the sewage of a city is almost sure to contain hosts of dangerous bacteria, and it should be disposed of in the safest and most careful manner possible. If it enters a river, and the water of the same river is used for drinking, many cases of typhoid fever are almost sure to arise. Most of the sewage of a city enters into common sewers, and each house is connected with these sewers. It is necessary, therefore, to have means for preventing the bacteria in the sewers from entering the house. This is accomplished by properly devised *plumbing*. We can thus comprehend the importance of having and keeping the plumbing of a house in good condition.

2. Bacteria may be transferred by **contact**, either actual contact with a patient or with something that he has touched. A nurse may get bacteria upon her hands from handling the patient or his clothing. If she washes her hands frequently and refrains from putting her fingers to her mouth, the danger from conta-

gion will be largely reduced. Other persons in the house may take a contagious disease by using spoons, knives, forks, cups, or saucers which have been employed in the sick room. Bacteria cling to such articles, and may thus be transferred to any person using the dishes. The danger may be avoided by allowing no one to use the same eating utensils as the sick person, or by washing them thoroughly in boiling water before they are used by others. Bacteria are also frequently left by sick persons upon door knobs, stair rails, etc., and these should, therefore, be carefully washed. In general, it is an excellent rule always to wash the hands before eating, and to avoid eating food which has been handled by others.

3. Bacteria may be carried by the air. When the skin peels, as in scarlet fever, or when there is a skin eruption, as in smallpox, the germs probably pass into the air, and may thus be carried to other persons. The same is true of diseases with which there is a cough, such as whooping cough and consumption. It is not very easy to guard against this danger if we must stay in the same room with the patient; but the danger may be reduced, as much as this is possible, by insisting upon a constant supply of fresh air in the sick room. The germs, after floating in the air for a while, settle with the dust. Every time the room is swept or dusted they are stirred up again. Sweeping and dusting schoolrooms increases the chance of the spread of contagious diseases. So far as possible, wiping with damp cloths should replace sweeping and dusting. After the

bacteria have reached the out-of-door air, most of them are killed by the sunshine, although this is not true of the bacteria of all diseases.

4. **Uncooked food** sometimes distributes disease bacteria. This applies chiefly to water and milk. Water from a river receiving city sewage is the most common source of typhoid fever. Milk is occasionally the source of diphtheria, scarlet fever, typhoid fever, or diarrhœa. In case of epidemics from water, we may protect ourselves by having the water boiled before we drink it. The only protection against disease carried by milk is either to buy the milk from reliable sources or to boil it before it is used. Other foods which we eat uncooked, such as lettuce, celery, raw oysters, and fruit, are occasionally sources of disease. Cooking is an efficient safeguard against the danger.

5. Occasionally flies or other **insects** may carry disease germs, particularly those of cholera, typhoid fever, and some eye diseases. The chief precaution to be taken is, as far as possible, to prevent flies from alighting on our food or eating utensils. We have already learned that certain mosquitoes distribute malaria, and it is also true that they carry yellow fever.

Every one should bear in mind a few simple rules which, if followed, will help to prevent the spread of contagious diseases. They are particularly important in schools where children from many families are brought together.

Do not spit on the floor or sidewalk.

Do not put pencils or penholders into the mouth.

Do not put the fingers in the mouth.

Do not put money in the mouth.

Never put into the mouth anything that another person has had in his mouth (gum, bean blowers, whistles, drinking cups, etc.).

When coughing turn the face away from others, and avoid allowing others to cough in your face.

Wash the face and hands often.

By these means we may largely avoid the germs which might get into our bodies.

THE USE OF ALCOHOL

We have learned in previous pages that alcoholic beverages are quite unnecessary to health, and are in many cases extremely harmful. They interfere to a large extent with the perfect health and happiness of mankind. The question might naturally be asked, Why is it that people learn to use alcoholic beverages when these are not only of no use, but liable to do so much injury? There are three main reasons: —

(1) The boy *does not realize the risk* he is running. He does not expect that he will become addicted to the use of alcohol in such a way as to injure him. Commonly he does not know the danger that lies before him.

(2) The boy sometimes knows well enough that alcohol is dangerous and likely to do him harm, but *he thinks it manly to drink*, and is afraid of being called odd or priggish if he does not. But it is not manliness that causes a boy to follow his companions into a saloon. On the contrary, it is usually cowardice. He

is afraid that he may be laughed at. It is really the manly and courageous boy who dares to stay outside and to refuse to follow others into useless danger, and in the end his associates never fail to recognize and to admire his real courage and manliness.

(3) The third reason is the *desire to be social.* The boy finds that his companions drink beer, and he feels it more social to follow their lead, even at the cost of some danger to himself, than to oppose them, especially if they are a little older than he. He should remember that the kind of sociability that leads to a saloon, or into any other useless danger, had better be shunned. There is companionship far pleasanter than that which comes through a glass of beer, and there are friends more useful than those who invite one to a saloon or urge one to join in a social glass.

Reasons why Alcohol should be entirely avoided as a Beverage.—The only wise course is to let alcohol entirely alone. There are three important reasons for so doing:—

(1) It may do us *physical harm.* It is impossible for any one to tell where the injurious effects begin, or to say how much he may use without harm to himself. Small quantities are liable to lead to larger ones, and the habit of using alcohol is apt to cause an appetite which will result in untold evil. The only safety lies in avoiding alcoholic beverages altogether. Many a person who seemed strong-willed has to his sorrow found his will power insufficient to resist the *craving* which alcohol has developed.

(2) The constant use of alcohol, even in moderate amounts, frequently lowers one's moral tone and intelligence and thus *interferes with one's chance of success.* The parts of the city which show the greatest poverty are the parts which abound in saloons. Prisons are filled with men and women who have used alcohol. The use of alcohol not only means the waste of large amounts of money, but if continued, it has a tendency to reduce a person's chance in life. It frequently ruins ambition; it tends to destroy the power of attending strictly to work; it makes a man careless about fulfilling his responsibilities, and is likely to lead to loss of employment. Some corporations, especially railroads, refuse to put into responsible positions, such as those of engineers and switchmen, persons who use alcohol even "in moderation," or occasionally. It is therefore not simply those who use alcohol to *excess* who risk their chances of filling responsible positions. The use of alcohol is likely to bring a boy into a circle of acquaintances who will injure rather than benefit him. It is likely also, when he has become a man, to destroy his interest in his family and all that is good, and to lead him to live a life upon a low plane.

(3) Our example will *influence others.* We all have some responsibility for those about us, and to lead another, by our example, into a course of life that injures him, is a very serious thing, the results of which we cannot measure. When people see their friends using alcohol, apparently without being injured by it, they are very likely to think that they can do the

same. They may be led to use alcohol in excess, from seeing others use it in moderation. The moderate drinker is the one whom others try to follow. He is thus in a measure responsible for the downfall of the friend who, weaker than himself, tries to follow his lead.

The healthy boy or girl does not need alcoholic drinks and is better off without them. In using them he is running the risk of injuring his own chances of success in life, and an even greater risk of ruining the chances of his neighbor or friend. To live a clean life one's self, and to help others do the same, is the best means to happiness and success.

THE DUTY OF PRESERVING HEALTH

It is our duty to make the most of our opportunities in life. Whether we decide upon a business career or a profession, we are sure to find that, in the sharp competition of to-day, a good body and abundant physical health are wonderful aids in reaching the greatest success in life. Physical strength will give one power to become a leader among men. Failure to develop our powers to their highest extent will result in a life unsatisfactory to ourselves. It is our duty to set our ambitions high. There is no one who may not hope for success, and no one who should not endeavor to live a broad and useful life. The higher we aim, the higher the position we shall reach. It is perfectly right and honorable to determine to reach a responsible position in business, to acquire wealth and power, and to become

a person of influence. These things are possible to every Canadian youth who will make proper use of his opportunities. Without perfect health, however, success is likely to slip from the grasp. One of the best assurances for a successful life is a well-developed, active, healthful body.

We should remember that the body is a marvellous machine. Its value depends upon its being in a condition of the greatest efficiency. A locomotive with a leaking valve may still pull a few cars, but it is much less useful than a perfect engine. So our bodies, even when more or less out of order from abuse of one sort or another, may still keep alive and carry on some of the duties of life; but they will do less work than when they are in perfect condition.

The value of the human body as a machine is lowered by every form of *overindulgence*. *Intemperance* in eating, in talking, in playing, or in working reduces our chances of future success. Intemperance in eating and drinking injures digestion; intemperance in talking destroys confidence in our statements; intemperance in playing makes a boy unready for the more serious duties of life; intemperance in working makes him tired and dull. The study of our body teaches that any kind of indulgence results in a general lowering of the powers of body and mind, and makes us less capable of achieving the highest end in life.

The study of these pages has resulted in showing that two great fundamental laws for developing a perfect body and living a useful life are: —

(1) *Use every power you possess.*

(2) *Avoid the overindulgence of all appetites and all desires.*

QUESTIONS.

1. What is the purpose of medicine?
2. Why should medicine be avoided as much as possible?
3. What causes most contagious diseases?
4. What is meant by parasitic animals?
5. How are tapeworms and trichinæ taken into the human system? What is the result with each?
6. How are malarial organisms taken into the body?
7. How can the body best be protected against injurious bacteria?
8. How may the spread of contagious diseases be prevented?
9. How do the injurious bacteria pass from a person who has sores or boils? Scarlet fever or measles? Typhoid fever?
10. In what important ways may bacteria be carried?
11. Why should plumbing be kept in good condition?
12. How may bacteria be transferred through contact?
13. How may bacteria be carried in the air?
14. Why is wiping with a damp cloth better than dusting in a schoolroom?
15. How may bacteria in food be destroyed?
16. How can we reduce the danger of taking a disease distributed by coughing?
17. How may we prevent diseases being spread by insects?
18. Why should we have light and air in our sleeping rooms?
19. What three conditions most commonly lead a person to use alcohol as a beverage?
20. Why should alcohol be entirely avoided as a beverage?
21. What are the two fundamental laws of health and usefulness?

CHAPTER XIV

WHAT TO DO IN EMERGENCIES

THERE are many times when a knowledge of simple methods of procedure in case of accident is of great advantage, and occasionally such knowledge may be the means of saving life. Some possible emergencies, with the proper treatment, have been mentioned on various pages of this book.

Drowning. — See page 120.
Burns. — See page 177.
Broken Bones. — See page 132.
Dislocations. — See page 140.
Foreign Bodies in the Eye. — See page 221.
Freezing. — See page 178.

Treatment for Poisoning. — The treatment to be followed when one swallows poison varies with each kind of poison. The ordinary course should consist of three steps, although with certain poisons one of these may be omitted. In every case of poisoning **a physician should be sent for at once.** Until he arrives there are in most cases two things to do: (1) cause vomiting, and (2) administer an antidote to the poison.

1. Induce immediate **vomiting** so as to remove as much as possible of the poison from the stomach. This may be done by giving a teaspoonful of powdered mustard in a glass of warm water. After the mustard has been swallowed, tickle the back part of the throat with

the finger or a feather. If vomiting does not occur at once, repeat the dose in about ten minutes. Common salt will sometimes serve in the place of mustard if the latter is not at hand.

2. Administer some **antidote** to counteract the effect of the poison which remains in the body. The antidote to be used depends upon the poison. The most common poisons and their antidotes are given below. In their treatment vomiting should be induced, unless otherwise stated.

Acid poisons, like *sulphuric acid* (oil of vitriol), *nitric acid* (aqua fortis), *muriatic acid*, *oxalic acid*, *carbolic acid*, etc. In these cases the vomiting should be omitted, and three or four spoonfuls of soda or of baking powder should be given to neutralize the acid. Limewater or even soapsuds may also be used. Oxalic acid and carbolic acid, even when neutralized, remain poisonous. The services of a physician are needed to wash out the stomach.

Arsenic is an ingredient of *paris green*, many *fly powders*, and *green paints*. Mix some tincture of iron with baking powder and give the patient a spoonful of the brownish powder which appears. Administer every minute or two.

Lead. — Found in *sugar of lead*, *white lead* used by painters, *tinfoil* of tobacco coverings, etc. Administer a strong solution of Epsom salts or Glauber's salts.

Mercury. — Found in *corrosive sublimate*, used for various purposes, chiefly as a disinfectant. Omit try-

ing to induce vomiting and administer the white of an egg, or flour beaten up with milk or water.

Opium. — In *laudanum*, *paregoric*, *soothing syrups*, *cholera mixtures*, etc. Give strong coffee or aromatic spirits of ammonia (fifteen drops of the ammonia every few minutes). Use all means to keep the patient moving and to prevent his sleeping.

Strychnine. — Use chloroform or ether to relieve the violent spasms. Aromatic spirits of ammonia or bromide of sodium may be used, five grains of the latter every half-hour. Artificial respiration may be necessary.

The **after-treatment** for poisoning must be such as to combat dangerous symptoms which have arisen. This, however, must be left to a physician, and cannot be done without special knowledge of medicine.

Snake Bites. — The bites of poisonous snakes are not very common in this country. In biting, the snake forces a very violent poison into the flesh, which is soon carried over the body through the circulation. The first thing to do is to tie a handkerchief around the limb that is bitten, above the bite, and then insert a stick inside the handkerchief, twisting the stick so as to compress the blood vessels and stop the flow of blood. This will prevent the poison from flowing with the blood over the body. The wound should then be sucked to remove as much of the poison as possible. The poison does no injury in the mouth and no harm to the person who sucks it, if care is taken to empty the mouth at once. If the wound does not bleed, it should

be cut open to induce bleeding. Strong coffee should then be given, or a large dose of whisky.

Bites of Animals. — The bites of animals are liable to be poisonous. All such wounds should be thoroughly washed, and as a precaution against poisoning they should be rubbed with nitrate of silver or cauterized with a hot iron. It should be always remembered that a bite from the teeth of any animal is more likely to be serious than almost any other kind of wound.

Stings of bees and other insects may be relieved by placing a piece of cold mud on the spot. A weak solution of carbolic acid, one part to twenty of water, sopped on with a cloth, is useful. Common ammonia is also sometimes efficient in relieving the pain. If the sting is left in the wound, as is likely if it comes from a honeybee, it should be removed with the sharp point of a knife blade.

Mosquito bites may be commonly relieved by the use of ammonia water or carbolic acid solution, one part to twenty of water.

Cuts and wounds should first be carefully cleansed by washing them thoroughly with water that has been boiled, and if necessary should be cleansed further with a brush that has also been boiled. The wound may then be washed with diluted carbolic acid (one part of acid to twenty parts of water), or with strong alcohol, whisky, or brandy. A compress of clean cloth, that has been baked to destroy germs, should then be placed over the wound, covering it completely from the air and the germs in the air.

GLOSSARY OF TECHNICAL TERMS

Abdomen. — The lower cavity of the body, containing the stomach, intestines, and other organs.

Albumen. — One of the proteids, such as the white of egg.

Anterior root. — The branch of each nerve of the spinal cord which carries messages from the brain to the muscles. See Fig. 67.

Aorta. — The large artery carrying pure blood from the heart. See Fig. 21.

Aqueous humor. — One of the transparent liquids of the eye. See Fig. 75.

Arterial blood. — Blood that has been purified by passing through the lungs.

Artery. — A blood vessel carrying blood away from the heart.

Artificial breathing. — Breathing produced by moving a patient's arms and chest without action on his part.

Auricles. — The chambers of the heart that receive blood from the veins. See Fig. 24.

Axis cylinder. — The central thread in a nerve fibre. See Fig. 68.

Bacteria. — Very minute plants, usually in the form of rodlike fibres.

Ball-and-socket joint. — A joint that allows of free motion in all directions. See Fig. 53.

Biceps. — The front muscle of the upper arm. See Fig. 55.

Bicuspids. — Eight of the teeth, of which four are in each jaw, between the canines and the molars. See Fig. 9.

Bile. — The liquid secreted by the liver.

Bladder. — The sac which temporarily holds the kidney secretion.

Blood corpuscles. — Small solid bodies found in the blood. See Fig 20.

Blood heat. — The ordinary temperature of the body - 98.6° F.

Brain. — The central organ of the nervous system, located in the skull.

Breastbone. — The bone in front of the chest. See Fig. 42.

Bronchii. — The branches of the windpipe, one entering each lung. See Fig. 33.

Callosities. — Parts of the epidermis thickened as the result of friction.

Canines. — Four teeth just back of the incisors. See Fig. 9.

Capillaries. — The small blood vessels that connect the arteries with the veins. See Fig. 25.

Carbon dioxide. — The gas which results from the burning of carbon in oxygen.

Carpals. — The wrist bones. See Fig. 42.

Cartilage. — The tough, flexible material that forms the softer part of the skeleton. See Figs. 33, 42, and 50.

Casein. — A proteid contained in milk, the basis of cheese.

Cells. — The microscopic bits of living matter of which the whole body is composed.

Cereals. — Food materials obtained from grains, such as wheat, oats, rice, etc.

Cerebellum. — The back part of the brain. See Fig. 65.

Cerebrum. — The highest and largest part of the brain. See Fig. 65.

Chest, or thorax. — The cavity within the ribs which holds the lungs and the heart. See Fig. 38.

Choroid. — The middle coat of the eyeball. See Fig. 75.

Chyle. — The name given to food in the intestines after it is thoroughly digested.

Chyme. — The name given to the food mass when it leaves the stomach.

Clavicle. — The collar bone. See Fig. 42

Coagulation. — A change from a liquid to a solid condition that occurs in some liquids, such as the change that takes place in the white of an egg when it is heated.

Coccyx. — A small bit of bone at the lower end of the spinal column.

Contagious diseases. — Diseases which one person may "catch" from another.

Cords. See **Tendons**.

Corn. — A thickened portion of the epidermis, usually on the toes, caused by friction or pressure.

Cornea. — The transparent covering of the eye, in front. See Fig. 75.

Cranium. — The rounded part of the skull containing the brain. See Fig. 44.

Dermis. — The inner layer of the skin. See Fig. 61.

Diaphragm. — A tough muscular membrane separating the thorax and abdomen. See Fig. 38.

Dislocation. — The wrenching of bones out of position at a joint.

Distilled liquors. — Liquors made by separating alcohol from a fermented substance.

Duct. — A slender tube by which secretions are carried from a gland. See Fig. 11.

Dyspepsia. — The name given to certain diseases of the digestive organs.

Ear-drum. — The middle cavity of the ear. See Fig. 76.

Enamel. — The outer, hard covering of the teeth.

Epidermis. — The outer layer of the skin. See Fig. 61.

Epiglottis. — The lid covering the opening of the windpipe in the throat. See Fig. 12.

Epithelium. — A layer of cells covering various internal and external surfaces of the body.

Eustachian tube. — A tube leading from the middle ear to the mouth. See Figs. 12 and 76.

Excretions. — Waste materials that pass out from the body.

Exhalation. — Breathing air out of the lungs.

Facial bones. The bones forming the face. See Fig. 44.

Fat cells. — Minute drops of fat, such as exist in meat. See Fig. 2.

Femur. — The bone extending from the hip to the knee. See Fig. 42.

Fermentation. — A change occurring in sugar solutions by which alcohol is produced.

Fermented liquors. — Drinks made from simple fermented material.

Fibula. — The small bone in the leg below the knee. See Fig. 42.

Foramen ovale. — The opening from the middle ear into the inner ear. See Fig. 76.

Frontal bone. — The bone forming the forehead. See Fig. 44.

Fuel foods. — Foods used for developing heat and energy.

Gall-bladder. — A sac which collects bile secreted by the liver. See Fig. 13.

Ganglion. — A knot of nervous matter containing nerve cells. See Fig. 67.

Gastric juice. — The digestive fluid secreted by the glands of the stomach.

Glottis. — The opening from the throat into the windpipe. See Fig. 12.

Glucose, or grape sugar. — Sugar found, or similar to that found, in fruits.

Gluten. — A proteid derived from wheat and some other substances.

Gray matter. — A substance containing nerve cells, found in the brain and the spinal cord.

Gullet. See **Œsophagus.**

Hair follicles. — The little pockets from which hairs grow. See Fig. 62.

Hard water. — Water containing some mineral substance, usually lime.

Hemispheres. — The two halves of the cerebrum. See Fig. 66.

Hinge joint. — A joint in which the bones move in one direction only.

Humerus. — The bone extending from the shoulder to the elbow. See Fig. 42.

Ilium. — One of the bones of the pelvic girdle. See Fig. 42.

Incisors. — The eight middle front teeth. See Fig. 9.

Incus. — One of the bones of the ear. See Fig. 76.

Inhalation. — Breathing air into the lungs.

Intestine. — The long tube through which the food passes after leaving the stomach. See Fig. 13.

Iris. — The membrane surrounding the pupil of the eye. See Fig. 75.

Ischium. — One of the bones of the pelvis. See Fig. 42.

Kidneys. — The organs for taking from the body the waste products found in the urine. See Fig. 60.

Lachrymal duct. — The duct which carries tears from the eyes to the nasal cavity. See Fig. 72.

Lachrymal gland. — The gland which secretes the tears. See Fig. 72.

Lacteals. — Small tubes which carry fat from the intestine to the blood vessels. See Fig. 16.

Larynx, or "Adam's apple." — An enlarged part of the windpipe containing the vocal cords. See Fig. 12.

Ligaments. — Bands of a white connective substance, which join bones together. See Figs. 51 and 52.

Ligature. — A band drawn tightly around some part of the body, as, to stop bleeding. See Fig. 30.

Lime. — A mineral substance required for making bone.

Liver. — A large red gland lying near the stomach. See Fig. 13.

Lungs. — Two organs in the chest cavity which absorb oxygen and get rid of carbon dioxide. See Figs. 33 and 37.

Malleus. — One of the bones of the ear. See Fig. 76.

Mandible. — The jawbone. See Fig. 44.

Marrow. — A fatty material in the middle of the long bones. See Fig. 45.

Medulla. — The lowest part of the brain. See Fig. 65.

Medullary sheath. — Covering of the axis cylinder in a nerve fibre. See Fig. 68.

Mesentery. — A sheet of tissue wrapped around the intestines and filled with blood vessels. See Fig. 16.

Metacarpals. — The bones between the wrist and the fingers. See Fig. 42.

Metatarsals. — The bones between the ankle and the toes. See Fig. 42.

Milk-teeth. — The first teeth of children, which are later replaced by the permanent teeth.

Molars. — The large back teeth, twelve in number. See Fig. 9.

Muscle fibres. — The microscopic threads of which muscles are made. See Fig. 58.

Myosin. — A proteid contained in lean meat.

Narcotic. — A drug which dulls body action.

Nerve cells. — Minute bodies at the ends of nerve fibres, which cause and receive stimuli. See Fig. 69.

Nerve fibres. — The microscopic threads of which nerves are composed. See Fig. 68.

Nerves. — Long bundles of fibres which carry messages in the body.

Occipital — The bone forming the back of the skull. See Fig. 44.

Œsophagus, or gullet. — A tube extending from the throat to the stomach. See Fig. 13.

Oxidation. — A union of some substance with oxygen.

Oxygen. — A gas forming about one fifth of the air.

Palate. — The roof of the mouth.

Pancreas. — A large gland which secretes a fluid to digest proteids, starches, and fats. See Fig. 13.

Pancreatic fluid. — The fluid secreted by the pancreas.

Parasites. — Animals or plants which live on or in the bodies of other animals or plants.

Parietals. — The bones forming the sides of the cranium. See Fig. 44.

Parotid glands. — The salivary glands in front of the ears. See Fig. 11.

Patella. — A round bone in front of the knee. See Fig. 42.

Pelvis, or pelvic girdle. — The hip bone. See Figs. 38 and 42.

Petrous bone. — The very hard bone which contains the ear.

Phalanges. — A name given to the bones of the fingers and toes.

Pillars of Fauces. — Two curtain-like sheets between the mouth and the throat. See Fig. 10.

Pores. — The small openings in the skin through which sweat passes.

Posterior root. — The branch of each nerve of the spinal cord, which carries messages from the muscles and skin to the brain. See Fig. 67.

Proteids. — Foods which are useful for building body tissue, such as albumen, gluten, etc.

Pubis. — One of the bones of the pelvic girdle. See Fig. 42.

Pulmonary artery. — The artery which carries blood from the heart to the lungs. See Fig. 23.

Pulmonary circulation. — The circulation of blood from the heart to the lungs and back.

Pulse. — A wave of pressure which passes along the artery with each heart beat.

Radius. — One of the bones of the forearm. See Fig. 42.

Reflex actions. — Actions which take place without the exercise of will.

Rennet. — A ferment secreted by the stomach, which curdles milk.

Retina. — The sensitive surface at the back of the eyeball. See Fig. 75.

Sacrum. — The part of the spinal column between the hips.

Saliva. — The secretion, produced by the salivary glands, that moistens the mouth.

Salivary glands. — The glands which secrete saliva. See Fig. 11.

Scapula. — The bone of the shoulder blade. See Fig. 42.

Sclerotic. — The outer coat of the eyeball. See Fig. 75.

Secretions. — Materials produced by glands for the use of the body.

Sensory nerves. — Nerves which carry the messages to the brain, resulting in sensations.

Skull. — The bony box which holds the brain.

Spinal cord. — The part of the nerve system which extends down within the backbone. See Figs. 43 and 66.

Spinal nerves. — Nerves rising from the spinal cord.

Spine. — The name given to the backbone.

Spleen. — A small gland in the abdomen, whose function is uncertain. See Fig. 18.

Sprain. — The tearing or straining of ligaments at a joint.

Stapes. — One of the bones of the ear. See Fig. 76.

Sterilizing. — Heating some substance until all living organisms (bacteria) are destroyed.

Sternum. — The breastbone. See Fig. 42.

Stimulant. — A substance which excites some part of the body into unusual activity.

Stimulus. — A shock which causes a muscle or other organ to act.

Suspensory ligament. — A thin band that holds the lens of the eye in position. See Fig. 75.

Systemic circulation. — The circulation in all of the body except the lungs.

Tarsals. — The ankle bones. See Fig. 42.

Taste buds. — The organs of taste in the tongue.

Tear gland. See **Lachrymal gland.**

Tendons. — Bands of white substance uniting muscles with bone. See Fig. 56.

Thorax. — The chest.

Throat. — A cavity back of the mouth into which mouth and nose open. See Fig. 12.

Tibia. — The large bone extending from the knee to the ankle. See Fig. 42.

Tonsils. — Two rounded bodies at the back of the mouth. See Fig. 10.

Trachea. See **Windpipe.**

Tubules. — The tubes in the kidney that secrete urine. See Fig. 60.

Tympanic cavity. See **Ear-drum.**

Tympanic membrane. — A membrane stretched across the passage leading into the ear. See Fig. 76.

Ulna. — One of the bones of the forearm. See Fig. 42.

Urea. — The chief waste product of muscle action, secreted by the kidneys.

Ureter. — The duct leading from the kidney to the bladder. See Fig. 60.

Uvula. — A small piece of the soft palate hanging downward from the back of the mouth. See Fig. 10.

Vaso-motor nerves. — A series of nerves controlling the size of the small blood vessels.

Vein. — A blood vessel carrying blood toward the heart.

MICROCOPY RESOLUTION TEST CHART

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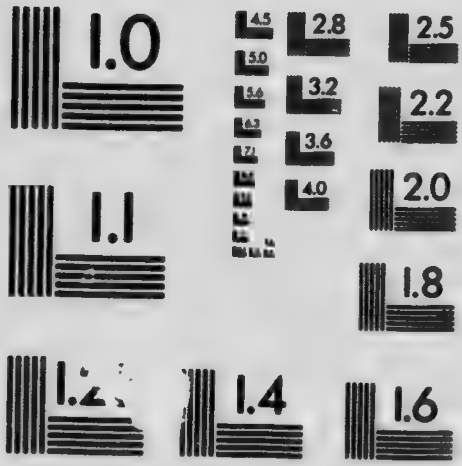

Venous blood. — Blood made impure by gathering up the waste of the body.

Ventricles. — The chambers of the heart that send blood into the arteries. See Fig. 23.

Vermiform appendix. — A small projection from the end of the large intestine. See Fig. 13.

Vertebræ. — The bones forming the backbone. See Fig. 43.

Vertebrates. — Animals possessing backbone and vertebræ.

Villi. — Little projections on the inside of the intestine for absorbing food. See Fig. 17.

Vitreous humor. — One of the transparent liquids of the eye. See Fig. 75.

Vocal cords. — Two membranes in the larynx whose vibrations produce the voice.

White nerve matter. — That part of the nervous system composed mostly of nerve fibres.

Windpipe, or trachea. — The tube leading from the throat to the lungs. See Fig. 12.

INDEX